AN OPTIMAL TECHNIQUE OF PMU PLACEMENT FOR ROBUST POWER SYSTEM ESTIMATOR

BY

MOHAMMAD SHOAIB SHAHRIAR

A Dissertation Presented to the

DEANSHIP OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

In

ELECTRICAL ENGINEERING

MAY 2018

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN- 31261, SAUDI ARABIA

DEANSHIP OF GRADUATE STUDIES

This thesis, written by Mohammad Shoaib Shahriar under the direction of his thesis advisor and approved by his thesis committee, has been presented and accepted by the Dean of Graduate Studies, in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING**.

Dr. Ibrahim Omar Habiballah
(Advisor)

Dr. Ali Ahmad Al-Shaikhi
Department Chairman

Dr. Mohammad Ali Abido
(Member)

Dr. Salam A. Zummo
Dean of Graduate Studies

Dr. Ibrahim Mohamed ElAmin
(Member)

28/8/18

Date

عمادة الدراسات العليا
DEANSHIP OF GRADUATE STUDIES

Dr. Zakariya Al-Hamouz
(Member)

Dr. Salim Ibrir
(Member)

To all my teachers

Who loved, cared, guided and inspired me

From the day of learning A-B-C until the day of Ph.D. defense

ACKNOWLEDGMENTS

All the praises belong to *Almighty Allah* who has created the whole universe. The reason behind all my success is nothing but His continuous mercy and kindness upon me. I am thankful to Allah for my every single puff of Oxygen. I wish I could be a better servant to Him.

Heartfelt respect and gratitude to the *Prophet Muhammad* (صلى الله عليه وسلم) who is undoubtedly the best human being ever came into the earth and therefore, the role model for the human being.

Dr. Ibrahim Habiballah is the person I would like to express my gratitude first for not only being an efficient supervisor of my dissertation but also for playing the role of a guardian in this tough journey. I will always cherish the way he appreciated my every single good work and the way he mentored me with his extremely supportive nature.

Special thanks to my committee members: *Dr. ElAmin, Dr. Abido, Dr. Zakariya and Dr. Salim Ibrir* for their insightful advice and guidance to enrich my Dissertation.

I like to remember my parents, *Dr. Shahjahan and Dr. Taslima*, with respect, for being the most supportive parents of the world. Their prayer for me is always the biggest strength of mine, Alhamdulillah!

Thanks to my beloved wife, *Rowshan*, for always showing up with smiley face and thus encouraging me to fight back in tough times. Presence of you and our son *Zawad* beside me has always kept me in sheer happiness.

Hat tip to my elder brother, *Dr. Saqif Shahriar*, for being a true inspiration in my academic career. I want to remember all my beloved teachers from my school, college and university level, with respect, for giving me such a wonderful academic life. I am grateful to my workplace Independent University, Bangladesh (IUB) for granting my study leave and supporting me to pursue higher education.

A big shout-out goes to all my friends, relatives and colleagues who always loved, inspired and supported me. Thanks are due to the *Bangladesh Community of KFUPM*. I must mention some names, especially, whom I found always beside me in my PhD tenure: *Saiful Islam Shourov, Ilius Pathan, Juel Rana, Md Shafiullah, Shafiul Alam, Imtiaz Hussain, Imran Reza* and *Asim Ghalib*.

Special gratitude to my friend and brother *Farhan Ammar Ahmad* with whom I started walking in this research field. I always found him as a 'friend in need' who made my research phase of Ph.D. enjoyable indeed. Many thanks to *Huthaifa* also for his valuable times, supports and suggestions.

Thanks. May Allah bless us all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CC	**:**	Covering Critical
EMS	:	Energy Management System
GA	**:**	Genetic Algorithm
HLMR	**:**	Hybrid Least Measurement Rejected
LMR	:	Least Measurement Rejected
MI	**:**	Multiple Interacting
MNI	**:**	Multiple Non-Interacting
NCE	:	Normalized Cumulative Error
NCC	**:**	Not Covering Critical
OPP	**:**	Optimal PMU Placement
PMU	:	Phasor Measurement Unit
PSSE	:	Power System State Estimation
SBD	**:**	Single Bad Data
SCADA	:	Supervisory Control & Data Acquisition
ULMR	**:**	Updated Least Measurement Rejected
WLS	**:**	Weighted Least Square
WLS-PP	**:**	WLS with Post-Processing

WLAV	:	Weighted Least Absolute Value

ABSTRACT

Full Name : [Mohammad Shoaib Shahriar]

Thesis Title : [An Optimal Technique of PMU Placement For Robust Power System State Estimator]

Major Field : [Electrical Engineering]

Date of Degree : [May 2018]

The evolving complexity and expansion has increased the amount of uncertainties in the electric power system. An efficient power system always ensures the protection, monitoring and efficient control of the power-flow from the generation end to consumers. Remote terminal units (RTU's) collect the meter readings from various parts of the network and send them to supervisory control and data acquisition system (SCADA) for further processing. When these meters are properly distributed in the system and have small errors, state estimation (SE) will provide close to accurate state variables of the system. However, if these meters have erroneous information (bad-data), then a robust estimator is required to filter out bad meters and provide good estimation of the system's states (voltage-magnitudes and phase-angles). Accurate estimation ensures the efficiency of energy management system (EMS) in monitoring and controlling the power system. Consequently, dealing with such bad-data)single or multiple) is one of the major challenges in the field of power system state estimation (PSSE). Existing robust estimators either fail to filter out bad-data or take longer time to have successful performance, especially when bad-data are multiple ones.

This dissertation presents the development of two versions of a robust estimator capable of handling single as well as multiple bad-data accurately and efficiently. These are the hybrid least measurement rejected (HLMR) and updated least measurement rejected (ULMR). HLMR is formed by hybridizing two of the eminent estimators: weighted least square (WLS) and LMR. This estimator is developed for those electric utilites that already using WLS in their EMS system. ULMR, on the other hand, is developed if the electric utility is installing a new robust estimator.

Phasor measurement unit (PMU) is a deliberate choice in modern-day power systems for its unique capacity in providing synchronized phasor readings of bus voltages and currents, with high accuracy. However, due to high expense and requirement of communication facilities, installation of a limited number of PMUs in the network is a frequent practice. This dissertation presents an efficient approach to select the optimal locations of those to-be-installed PMUs with the objective of ensuring the maximum estimation accuracy.

IEEE 14-bus, 30-bus and 118-bus power systems have been used for performance evaluation of the two proposed estimators: HLMR and ULMR in the presence of single, multiple-interacting and multiple non-interacting bad-data. The performance of the proposed estimators is compared with the widely used WLS estimator, and the robust Weighted Least Absolute Value (WLAV) estimator. Optimization of PMU placement is tested on the proposed estimators and the impact of including PMU meters on the estimation performance is investigated.

ملخص الرسالة

الاسم الكامل: محمد شعيب شهريار

عنوان الرسالة: تقنية لتحديد الأماكن المُثلى لوحدات إدارة القدرة لمتوقع قدرة كهربية كفء.

التخصص: الهندسة الكهربائية

تاريخ الدرجة العلمية: مايو 2018

عدم الدقة فى أنظمة القدرة الكهربية والناجمة عن تطورها وتعقدها يتطلب وجود نظم ذات كفاءة للحماية و المراقبة والتحكم الكفء فى تدفق القدرة من المصدر إالى المستهلكين. ولذلك فإن الوحدات الطرفية عن بعد تقوم بتجميع القراءات خلال الشبكة وإرسالها إلى وحدة التحكم ومعالجة البيانات ويستلزم معها التوزيع السليم لأجهزة القياس لضمان الحصول على معاملات أكثر دقة لوصف أداء الشبكة. لكنه يتطلب وجود مرشح معلومات قوى قادر على التخلص من معلومات أجهزة القياس الغير قيمة والتوقع الجيد لحالات النظام متمثلة فى قيم الجهود وزوايا الازاحة حيث أن التوقع الدقيق يضمن كفاءة نظام إدارة الطاقة فى المراقبة والتحكم. لذلك التعامل مع هذه المعلومات الغير قيمة يعد تحديا كبيرا فى مجال نظم توقع القدرة الكهربية علما بأن الانظمة التوقع الموجودة غير قادرة على التخليص من هذه المعلومات الرديئة و تستهلك وقتا كبيرا لتحقيق أداء مرضى خاصة حال المعلومات الرديئة المتعددة. هذا البحث يعرض تطوير نموذجين (ULMR ، HLMR) لمتوقع قوى قادر على التعامل مع هذه المعلومات سواء فردية أو متعددة بكفاءة ودقة. و يدمج المتوقع HLMR بين نوعين معروفين من أنظمة التوقع هما (WLS) و (LMR) وتم تطويره للوحدات الكهربية التى تستخدم فعليا WLS فى نظام ادارة الطاقة. بينما يستخدم نظام ULMR كمتوقع صلد مع الوحدات الحديثة الإنشاء.

تعد وحدة قياس الإزاحة من الوحدات المستخدمة فى أنظمة القدرة الكهربية الحديثة لسعتها المتميزة فى ايجاد قراءات الازاحة المتزامنة للجهود والتيارات بدقة عالية. ولكن للتكلفة المرتفعة ووسائل الاتصال المطلوبة فإن تركيب مثل هذه الوحدات فى الشبكة محدود عمليا. هذا البحث يعرض منهج كفء لإختيار المواقع المناسبة لتركيب هذه الوحدات مما يترتب عليه تعظيم دقة التوقع. يستخدم كلا من أنظمة القدرة IEEE 14-bus و 30-bus and 118-bus لتقييم أداء نظامى التوقع المقترحيين فى هذا البحث فى وجود معلومات غير قيمة فردية ومتعددة متفاعلة وغير

متفاعلة. وتم مقارنة أداء النظامين المقترحين مع نماذج التوقع كثيرة الإســـتخدام مثل (WLS) و (WLAV) لتوضيح مدى كفائتهم وتأثير استخدامهم.

CHAPTER 1

INTRODUCTION

1.1 Research Background

In the 1950s, the power systems were using analog computers to conduct economic dispatch (ED) and load-frequency control (LFC) after collecting the power outputs and tie-line flows from the power plants by analog communication. LFC was maintaining the required frequency as well as interchanging schedules between the control areas. ED provides the optimal power outputs for the generating units which meets the load demand with minimum total cost.

With the introduction of digital computers in 1960s, the process of collecting real-time measurements of power flow, voltage and circuit breaker status was started. This data collection process is known as remote terminal units (RTUs) which sends all such information to a central computer capable of doing necessary process of automatic generation control (AGC). AGC is kind of a combination of ED and LFC which could do the operation of controlling the generation level and status of the circuit breaker. This overall system is known as supervisory control and data acquisition (SCADA).

After the 1965 blackout in northeast USA, the power engineers felt the necessity to develop a sophisticated tool which can collect, transmit and process measurements from all the meters installed over the network. This step of supervision was taken just before the establishment of modern energy management system (EMS) which can do various sophisticated works like data acquisition, state estimation process, load flow analysis, economic dispatch, voltage-frequency control and security assessment of the system.

Large power systems have lots of parameters (voltage, current, power-injection, power-flow) to be monitored which has made it very impractical and non-feasible to place the meters everywhere. Moreover, the measurements are not always correct due to environmental noise, communication failure and other type of meter errors. Thus, the challenges like intermittent generation, congested transmission corridors and massive exchange of power between areas has asked for improving the current practice of monitoring the power network in real-time and to explore new tools that can be used to analyze the acquired real-time data.

Efficient technologies like phasor measurement unit (PMU) and robust state estimators are being used for this purpose to deal with the complicated network operation over a range of possible conditions imposed by the uncertainty of intermittent generation and demand.

1.1.1 State Estimation (SE)

Power systems nowadays are highly complicated and interconnected in nature. Systematic interconnection was made to strengthen the networks and to facilitate the transmission of electricity. This has brought the new operation challenge of monitoring the whole network in real-time to ensure the stable and secure functioning of power-flow from generation end to consumers.

State estimation process is one of the most important components in the field of modern day power system which is used by the system operators to analyze the whole network in real time [1]. An estimator can estimate the states (voltage-magnitude and phase-angle) of the system bus-bars by processing the raw and redundant meter readings, provided that the network topology is provided. MIT professor Fred Schweppe first proposed the idea of state estimation in the year 1968. Since then, the idea has been adopted and implemented throughout the world in energy control centers (ECCs) of electric utilities and independent system operators (ISOs) [2], [3]. It has been considered as the backbone of the energy management system (EMS) for it's unique role in ensuring the secured operation of power system. Continuous monitoring of the system states by the estimator guarantees the reliable operation of the power system.

SCADA system plays the most key role in the estimation process. RTUs are installed in various locations of the power system which transmits the meter readings to the SCADA system operators for monitoring purpose [4], [5]. It is possible to control the RTUs by the operators of ECC. Usually, RTUs can record all the switching statuses of the transformer taps and the circuit breakers. Besides, it records all the available measurement values of voltage-magnitude, real and reactive power-flows, real and reactive power-injections and the current magnitudes. RTU does the scanning and refreshing in each 2-4 second to receive the new set of measurements from the meters as well as the switching statuses. Usually, microwave radio and the telephone wires were used for maintaining this communication channel. In recent times, newer mediums of communication like satellites, fiber optic, internet system, spread spectrum radio are taking the place of the old mediums of communication. This increased the speed, reliability and efficiency but with the cost of higher expense [6].

Error! Reference source not found. shows the complete process of state estimation [7].

Topology processor does the job of processing all the on/off statuses of the available switching devices sent by RTU and thus the topology of the network is determined. It characterizes the connection pattern between the buses, presence of the shunt element, location of those and the connection pattern with generators and loads by using one-line diagram. The status notification of the switching devices can be denoted as bus section breaker-switch data which is converted to bus-branch one-line diagram pattern by topology processor. One-line diagram presents the connectivity pattern of each of the bus, transmission line and shunt transformer more precisely and easily [8].

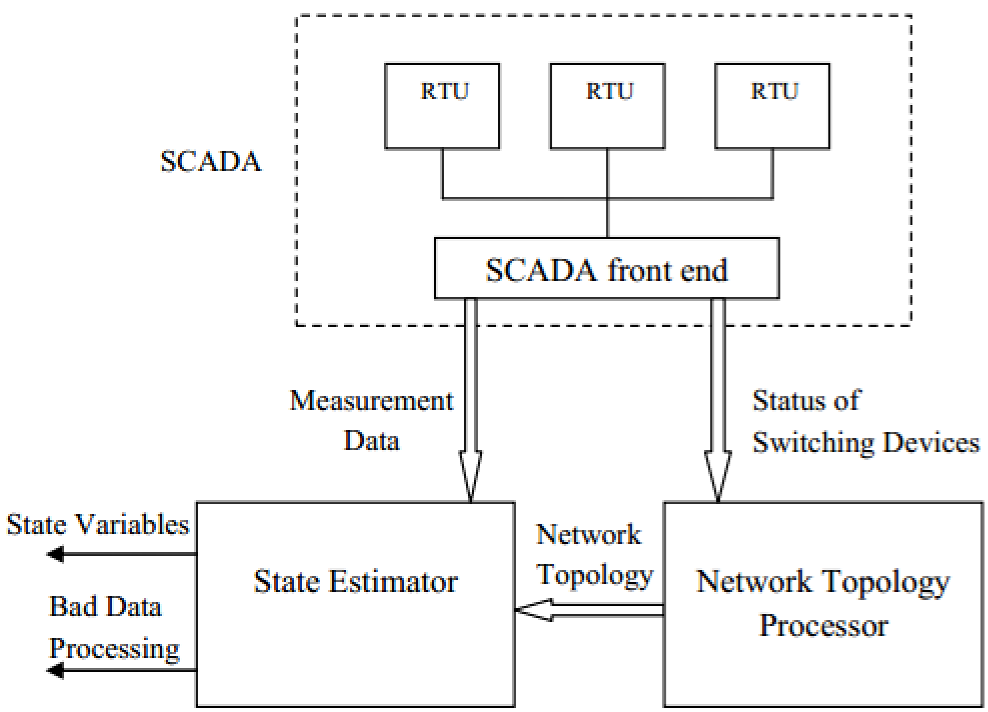

Figure 1.1 Working procedure of an estimator [7]

It is very important to get the proper information from the topology processor to determine the system states properly. But unfortunately, many topology processors can't acquire the proper switching information from the breakers and switches because of weak communication channel. This creates the problem of topology errors which is very common phenomenon in this field.

Besides, there are some other types of factors which affects the performance of a state estimators like gross errors in measurements and transducers, parameter errors in the data base and the unsynchronized nature of conventional measurements.

However, the development of synchronized measurement units has opened new opportunities to better monitor the power networks. PMU meters are now started to be used in the modern power systems with their accurate and synchronized phasor measurements, which certainly improves the entire process of accurate estimation. Development of the techniques to add these synchro-phasors in the existing system is going on.

Measurements fed by the SCADA system and the system topology is sent to estimator which does the main work of estimation. If the estimator is not robust and can't handle with the wrong measurements, then it is needed to use a separate bad-data processing unit to detect, track and eliminate the bad-data. The use of an efficient robust estimator can replace the necessity of such bad-data processing unit.

1.1.2 Phasor Measurement Unit (PMU)

The phasor measurement unit (PMU) is a device which can measure the synchronized voltage and current phasor in a power system. Global positioning system (GPS) is used to provide a time-stamp to each of the voltage and current phasors. Within a time interval of 1 microsecond, GPS provides the common synchronized time signal to the measurements and the accurate values of voltage and current phasors are obtained. Thus, PMU has become the most reliable and expected measuring device in the field of power system monitoring and control [9].

A generic functional block of PMU [10] is presented in **Error! Reference source not found.**. The secondary winding of voltage and current transformers provide with the analog input of voltage and current, respectively. Frequencies over the Nyquest rate are attenuated by the anti-aliasing filter. Phase-locked oscillator provides the high-speed pulses which is used further in waveform sampling. The A/D converter converts the analog signals (voltage and current) into digital which is then transmitted to phasor microprocessor to execute the discrete Fourier transform (DFT) phasor calculations. All the collected phasor values are then assembled in a phasor data concentrator (PDC) and finally transmitted to the modem.

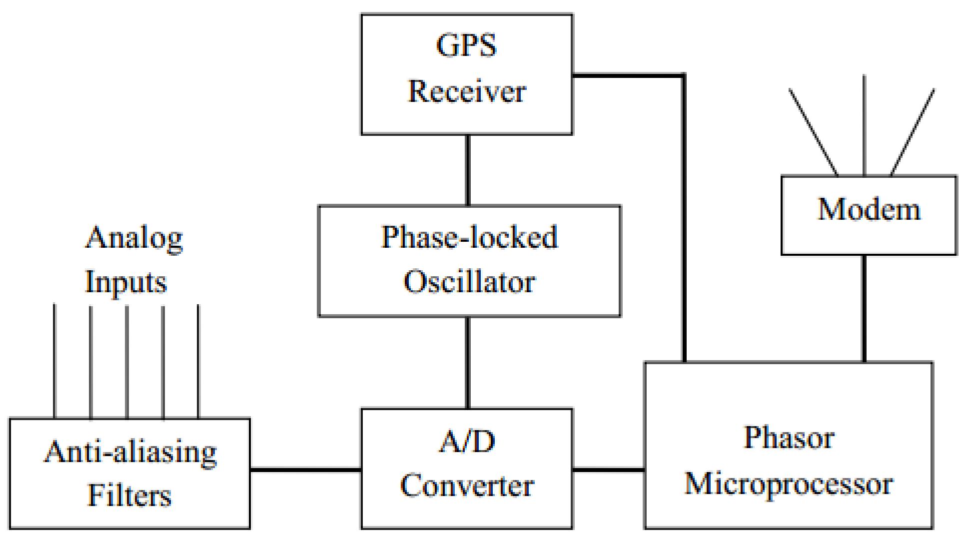

Figure 1.2 Working procedure of an estimator [7]

PMUs are being used in the field of power system protection in the recent years. Phasor measurements provided by the PMU meters increases the efficiency of monitoring and control of system network. Whenever any PMU is being installed in power systems, voltage and current phasor measurements are being added along with the conventional SCADA measurements which will eventually increase the accuracy of the state estimator [11]–[13].

1.2 Motivation

In the year 2003, the most severe power outage in the history of North America took place. More than 50 thousand people had to stay without electricity for long 48 hours which resulted in at least 11 deaths and cost the economic loss of about $6 billion. The investigation team founded the reason of the incident later and reported that the monitoring computer running the estimation was not functioning at that very moment due to the software glitch and it made the scenario worse. It has been investigated that, as the most conventional state estimation programs like WLS work fine under normal load conditions but prone to collapse in special situations. Researches are going on for years to innovate new ideas in this field to overcome the challenges faced in practice. Several approaches has already been implemented in different power systems to improve the robustness of the estimation performance.

Preparation of robust estimator has thus become a major motivation to carry on this research work. Two well-developed robust estimators are proposed in this dissertation which can withstand different sorts of bad-data scenarios even if the presence of bad-data is multiple in number.

Another way of improving the estimation accuracy is to use the PMU meters in the power system and to place them in the correct locations of the power system. Placing PMUs properly in power system has become one of the most vital issues since it arrived in market. PMUs are highly expensive and require special communication facilities in the installed buses. So, it is needed to develop a strategy to find the optimal PMU locations if any power system intends to install any limited number of PMUs with the existing conventional SCADA meters. Thus, the motivation has driven this research to develop a technique of finding the optimal locations of a limited number of PMUs to be installed in the power system. The optimization also reduces the threat of bad-data occurrence by covering the critical zones and therefore, makes the estimator more efficient.

1.3 Objectives

The main objectives of this dissertation can be summarized as follows:

- To develop a hybrid robust estimator that can handle bad-data presence accurately and efficiently. It can be installed along with existing WLS estimator.
- To develop an updated version of estimator LMR that can handle bad-data presence accurately and efficiently. It can be installed as a standalone state estimator algorithm.
- To investigate the performance of the proposed estimators with different bad-data scenarios: single bad-data, multiple interacting bad-data and multiple non-interacting bad-data.
- To compare robustness of the proposed estimators with other existing robust estimators in terms of both accuracy and computational efficiency.

- To investigate the performance of proposed estimators after inclusion of PMU meters in the SCADA-based power system.
- To find the optimal locations when incorporating any limited number of PMUs.
- To investigate the performance of the estimation process in the presence of bad-data when enforcing the critical buses with PMU meters so that the negative effect of bad-data presence could be minimized.

1.4 Contribution of This Dissertation

In order of appearance, the major contributions of this dissertation are as follows:

- Development of a hybrid robust estimator (HLMR) inspired from using both WLS and LMR in the estimation process. The proposed estimator can be implemented in electric utilities using WLS estimator. This will enhance the performance of EMS system in the presence of sever bad-data scenarios.
- Development of a robust estimator (ULMR) which uses a novel approach of tolerance selection for each measurement. The proposed estimator can be installed as a standalone estimator in the power systems, without any post-processing feature. This version of robust estimator has the capability of producing fast and efficient estimation of the states even in the presence of sever bad-data scenarios.
- Incorporation of the voltage and current phasors into the existing Jacobian matrix of the proposed estimators. This allows the proposed estimators to work with PMU readings along with the conventional SCADA measurements.
- Formulation of an optimization problem which can provide the optimal locations of any limited number of PMUs by ensuring the best estimation performance.

Reduction of the effect of bad-data presence in estimation performance by enforcing PMU's on critical busses.

1.5 Dissertation Outline

The remaining dissertation is designed as follows:

Chapter 2 presents the literature review on state estimation as well as on the optimization of PMU placement.

Chapter 3 presents all the estimators which are used in this dissertation in details. Formulation of weighted least square (WLS) and weighted least absolute value (WLAV) is shown as they are used for comparison purpose. Besides, two proposed robust estimators: hybrid LMR and updated LMR are presented with detail formulation. Some of the key factors which impact SE performance like observability, bad-data, critical measurement, redundancy, presence of phasor measurements in estimation etc. are also discussed in this chapter.

Chapter 4 describes about phasor measurement unit (PMU) along with its importance and application fields. This chapter also shows the proposed technique of PMU placement optimization using genetic algorithm (GA). GA, along with its different steps in solving the proposed optimization problem is discussed in detail.

Chapter 5 presents the simulation results of estimation performance. The measurement simulation procedure, preparation of the test cases and the simulation results are presented with tables and graphs. Comparison between the proposed two estimators with WLS, post-processed WLS and WLAV has been presented in this chapter, under different scenarios.

Chapter 6 presents the results of PMU placement optimization. Optimal locations for different sets of PMUs is presented for two proposed estimators: HLMR and ULMR. Comparison with the heuristic approach of optimization and significance of covering the critical zones by PMUs are also discussed in this chapter.

Chapter 7 concludes the dissertation, presents the publication outcomes from the dissertation and proposes some future works.

Appendix A presents the single line diagrams, line data, bus data, meter distribution of the test-cases along with the load-flow and measurement values of 14-, 30- and 118-bus power systems.

Appendix B includes the detail simulation results for 14-, 30- and 118-bus power system under various scenarios. The results are presented in CD.

CHAPTER 2

LITERATURE REVIEW ON STATE ESTIMATION AND PMU PLACEMENT

This chapter presents the literature review on state estimation and phasor measurement unit. Extensive literature review on optimal PMU placement (OPP) is also presented in this chapter. Incorporation of PMU meters in an existing power system has some impacts, which are discussed at the end of this chapter.

2.1 State Estimation Algorithms

In the year 1968, an MIT professor named Fred Schweppes, who was working with American Electric Power in New York city that time, first came with the idea of state estimation process. He noticed that the problem of missile tracking follows the similar concept of estimating the states of a power system. To track the exact location of a missile, multiple number of radars gather the information about distance, speed and other parameters. Based on this idea, Dr. Fred proposed that a power system state estimator should be able to predict the exact states by processing raw and redundant conventional meter readings and other information about electric power system [2], [3]. Voltage-magnitudes and the angles of the buses are considered as the states of the power system.

Therefore, all other power system parameters can be calculated from the estimated states, if the system data is known.

The presence of faulty meters and inaccurate topological parameters is a common phenomenon in the modern-day interconnected power systems. To control and monitor such a system, accurate estimation of the system states is must. Control center receives meter measurements from sensors like current transformer (CT), relay, potential transformer (PT) and phasor measurement units (PMU) situated at various parts of power grid. The utilities can monitor the operating condition of the system by processing the received measurements through estimation process. The state estimator optimizes an objective function which is non-linear and could be of first order or second order [8].

In literature, several approaches of state estimation techniques has been presented, considering the practical difficulties.

Weighted least square (WLS) is the classical approach of doing the state estimation which is mostly used by the power systems throughout the world [8], [14]. WLS assumes that the measurement errors are independent to each other and distributed according to Gaussian distribution with zero mean and known variance. Measurement error variance is selected based on reliability of the meter, the more reliable meters are given least variance values. Objective function of WLS is solved by Newton Raphson procedure of iteration. In literature, WLS is presented using sparse orthogonal decomposition or normal equations approach by solving sequence of linearized problems [15]. The WLS fails in the case of bad-data presence but performs very well under Gaussian errors [16]. Iteratively reweighted least square (IRLS) estimator has been presented in [17] which updates the values of applied weights in each iteration and thus shows significant robustness in estimation.

Several attempts are made for solving PSSE problem by heuristic optimization techniques. But it results in falling trapped with local optima instead of global solution and therefore, results huge error between estimated values and actual ones. Among the intelligent techniques, Fuzzy interference system, neural network, adaptive neuro-fuzzy interference system is tried in state estimation process. It has been found that the mathematical methods are not faster than intelligent methods but are more accurate [18]. A genetic algorithm approach to solve adaptive state estimation is proposed in [19] which presented the use of genetic adaptive state estimator for estimating the states. Particle swarm optimization (PSO) is proposed in [20] for solving power system state estimation which requires least computation time and memory.

Telemetered values provided by the measuring equipment's can be mixed with random noise. Moreover, gross errors could happen due to equipment malfunction or erroneous collection of meter reading. Such types of wrong measurements are known as bad-data. Several robust estimators are presented in the literature which can withstand bad-data. Quadratic constant (QC), quadratic root (QR) and quadratic square root objective function based algorithms are proposed in references [21]–[23]. They try to minimize the objective function of measurement error during estimation process. Equivalent linear programming (LP) based least absolute value (LAV) estimator is presented in references [24]–[27]. It is one of the widely used robust estimators. Weighted LAV [24], [27] and iteratively reweighted LAV [25], [28] are the updated versions of the LAV algorithm. LAV estimator is well known for its robustness though it is found susceptible to leverage points for some meter configurations and systems. Least median square (LMS) and least trimmed square (LTS) estimators are updated version of the LS algorithm [29][28]. However, both require many variables (binary and continuous) and constraints to deal with in the formulation. Therefore, they suffer from computational burden largely. LMS has the specific drawback of rejecting some good measurements along with the outliers, during the estimation process. LTS considers the sum of squared errors for (m-K) number of residuals only. A Diakoptic theory based robust estimator is presented by Jiang et al. [31]. Mixed integer quadratic programming (MILP) based on rounding off technique is proposed in [32] which deals with discrete and continuous variables at the same time.

One of the useful robust estimators using MILP is least measurement rejected (LMR) algorithm which was first proposed by M. Irving [33]. LMR does a regression process to estimate the states of the system after rejecting certain measurements. Comparison of this estimator with other robust estimators is presented by different authors. LMR is compared with other robust estimators such as LS, LAV, LMS, LTS, QC, QR etc [34], [35], [36], [33], [37], [38]. Tolerance (T) is a key parameter in the formulation of LMR. The authors focused on the importance of choosing proper values of *T* for LMR. However, the selection process for the appropriate tolerance values for each meter is not presented.

Among the published papers on LMR, reference [39] investigates the bad-data rejection capacity of LMR under different ranges of tolerance (0.1 to 5) for a small test-case but didn't propose any *T* selection process. Reference [37] denotes the term 'tolerance' as 'uncertainty range' and presented the values used in the paper in a table. But no approach of that range selection is proposed. Total of seven test-cases are investigated in [34] and found that the best value of *T* is different from one case to another. The paper presented the results for DC estimation only and a fixed tolerance is applied to each meter type. A fixed value of tolerance is used in [35], [36] and [38] for all the measurements. Recently, reference [40] proposed an iterative approach of tolerance value selection where a value of T is applied to all the measurements, irrespective of the type of the meter.

All the estimators mentioned in the dissertation are static state estimators. In dynamic state estimation process, the system states are continuously computed and monitored at specific regular time intervals. There are many methods like Kalman filter, invariant imbedding, nonlinear observer technique which are used in dynamic State Estimation process of power system[41][42]. There are alternative approaches which have been proposed like orthogonal factorization, hybrid method, augmented matrix approach, etc. [42].

In the recent days, a mixed integer linear programming (MILP) formulation of a robust estimator is presented in [43] which has used CPLEX is the solving tool and found time-efficient for even the larger systems. Another robust estimator is proposed in [44] which is designed on the concept of normal measurement rate (NMR) and the theory of uncertainty of measurement. Recently, a robust estimator is presented in [45] which is based on maximum exponential absolute value (MEAV) and solved by primal-dual interior point method. An LTS based robust estimator is proposed in [46] which uses the PMU meter readings along with the SCADA meters to estimate the states properly in the presence of bad-data.

2.2 Optimization of PMU Placement in Literature

Many researches have been done in the field of PMU placement. The purpose of the optimization is to improve the performance of the power system by ensuring the complete observability of the system with PMU meters. Different intelligent approaches has been proposed by different authors like genetic algorithm based on dominated sorting [47], simulated annealing and bisecting search based method [13], graph theoretic approach based on simulated annealing [48], integer programming (IP) based approach [49] etc. The bisecting search approach has been found computationally less efficient. Branch and bound method [50] and linear programming (LP) solver has been used widely for IP problem solving. In such cases, original problem is converted into a sub problem in branching stage and the sub problem is solved by an LP solver in bound stage. As LP process needs to be done in each iteration, it becomes computationally inefficient for larger systems. Binary search method [51] for finding out the global optima is suitable for some of the cases but largely depends upon the complexity of the system. A different way of phased installation process is proposed in [52] which leads the final placement as an optimal solution. To reach the complete observability with minimum number of PMU's, Tabu search metaheuristic algorithm has been proposed in [53]. PMU placement problem, converted into a multi objective optimization problem, is solved by differential evolution [54] based on non-dominated sorting. Another local search metaheuristic method [55] has been used for OPP where one PMU is placed before the approach starts. An exhaustive search method [56] is proposed for OPP which checks the topological and numerical observability separately in two different stages. However, this is not easy to handle computationally. Binary particle swarm optimization (BPSO) is proposed to meet the requirement of observability and cost minimization in [57] which is further modified and presented in [58]. Optimal PMU placement technique with contingency analysis is proposed in [59]. A heuristic approach is proposed in [60] which considers zero injection bus as pseudo measurement. With the presence of single and multiple bad-data, optimal PMU location is found in [61] where the measurements are taken both from SCADA and PMU. Biogeography based optimization (BBO) for minimizing the number of PMU's is presented in [61] where a single branch/ meter outage is considered.

A topological observability rule [62] is implemented through binary imperialistic completion algorithm (BICA) with zero injection buses. Chemical reaction optimization (CRO) and also a simplified version of that is proposed in [63]. Cellular learning automata (CLA) is used for solving such kind of a multi objective optimization which has been found very effective in dealing with large scale complex power systems [64]. There are several works which has been done by some hybrid models of optimization techniques. Hybridization of genetic algorithm (GA) with minimum spanning tree (MST) algorithm is proposed in [65] and with simulated annealing is proposed in [66]. Bacterial foraging algorithm (BFA) is used with the presence of conventional measurements in [67]. A mixed integer programming model is proposed in [68] which can be applied for both AC and DC system. This work considers variable costs for different PMU installation which depends upon the measurement channels as well as the number of installed PMUs. Artificial bee colony (ABC) is used to search the optimal number and location of PMUs in [69] to ensure the system observability as well as the better estimation performance.

A two stage PMU placement technique has been proposed in [70] where the system has been made observable with all SCADA measurements first and then the PMUs are placed to make it redundant in second stage. Critical sets are found by calculating residuals which allows the optimal placement in second stage. A new approach of finding PMU locations for least absolute value (LAV) algorithm is presented in [71] which can detect bad data without finding out the critical sets. It also presents the concept for “branch PMU” which provides only a single voltage phasor and a single current phasor. Optimal PMU set is also presented in [59] for single bad-data presence and single line outage. It presents the technique of contingency calculation in measurement matrix and thus finding out the position vector of redundant measurement. This work proposes a binary integer programming approach to find out the PMU locations and then a heuristic approach to rearrange the locations to get the optimal set. [72] Proposes a global optimal strategy of PMU placement which tries to maximize the average detection performance under multiple line outages. It assumes that the budget to place each PMU is fixed and proposes exhaustive search optimal method to solve the optimization problem which is inspired by Kullback-Leibler distance. Two almost similar kind of works [73], [74] proposed bad data detection in PMU placement problem by modifying Jacobian matrix into cartesian format. No reference bus has been considered in this work. Observable islands are found from the critical sets and the PMUs are placed optimally to merge those islands and to make the whole system observable. Another algorithm has been proposed recently in [75] which can make the system observable, detect bad-data and suitable for mixed measurement cases. It finds out the node injection radix measurements and defines the measurement categories. Authors in [76] presented the technique to place PMUs optimally both in buses and in branches which will ensure system observability beside bad-data detection. This work also does contingency analysis to ensure the robustness of the system. Another different approach is presented in [77] which deals with Gain matrix and finds the rank of the Jacobian. It finds out the constraint equations in shorter form and thus reach the optimal solution in only 3-4 iterations. The algorithms for observability and bad data detection are presented separately and combined later. Jian Chen presented another way of PMU placement by modifying the Jacobian matrix [78].

2.3 Effect of PMU meters on SE performance

Traditionally, the power system monitoring is done with the help of raw dataset of the SCADA system. Real and reactive power flows, voltage magnitudes, circuit breaker status and transformer tapping information are collected by RTU and provided to SCADA. State estimation process is done with the available redundant measurements which provides the accurate estimation of the measurements and removes the bad-measurements from the system. PMU meter readings can be used in the estimation process along with the conventional meter readings [79]. The incorporation of the PMU meter readings on the state estimation process is having several impacts:

1. PMU provides the state variables (voltage phasors) directly as the measurements with high accuracy which improves the accuracy of the estimation [80].
2. Time synchronized measurements reduce the time skew of the estimation process significantly [81].
3. Covering the whole power system network with only PMU readings could make the nonlinear estimation work linear [82].
4. Careful placement of limited number of PMUs in the power system could make the critical locations redundant and thus can improve the robustness of the estimation process [80].

CHAPTER 3

STATE ESTIMATION ALGORITHM; THEORY AND FORMULATION

The dissertation proposed two robust estimators: hybrid least measurement rejected (HLMR) and updated least measurement rejected (ULMR). This chapter presents the formulation for both the estimators in detail. The significance of tolerance, a key parameter in the LMR formulation is discussed in a separate subchapter. The formulation of weighted least square (WLS) and weighted least absolute value (WLAV) is also presented, which are used for the comparison purpose. However, the process of including current and voltage phasors in the conventional Jacobian matrix is presented in detail. The modified Jacobian will be necessary for all the estimators while incorporating PMU measurements into the SCADA system.

3.1 Weighted Least Square (WLS)

Weighted least square uses the objective function to minimize the square of the error during estimation process. If the state estimator is using a set of measurements given by vector z, then the relationship of it with system states can be expressed as [14]:

$$z = \begin{bmatrix} z_1 \\ z_2 \\ . \\ . \\ z_m \end{bmatrix} = \begin{bmatrix} h_1(x_1, x_2, ..., x_n) \\ h_2(x_1, x_2, ..., x_n) \\ . \\ . \\ h_m(x_1, x_2, ..., x_n) \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \\ . \\ . \\ e_m \end{bmatrix} = h_i(x) + e \qquad (3.1)$$

here, *m* is the number of measurements and *n* is the number of state variables (voltage-magnitude and phase angle).

$h_i(x) = [h_1(x), h_2(x), ..., h_m(x)]^T$ is the nonlinear function relating measurements (*z*) to state variables (*x*).

$x = [x_1, x_2, ..., x_m]^T$ is the vector with power system states.

$e = [e_1, e_2, ..., e_m]^T$ is the vector of measurement errors.

The WLS estimator minimizes the following objective function [14]:

$$\min J(x) = \sum_{i=1}^{N} W_i \; | z_i - h_i(x) |^2 = \sum_{i=1}^{N} (z_i - h_i(x))^2 / R_{ii} \qquad (3.2)$$

here, *[R]* is called the covariance matrix of measurement errors and is related with the standard deviation values.

$$R = diag\{\sigma_1^2, \sigma_1^2, ..., \sigma_m^2\} \qquad (3.3)$$

Equation (3.2) can be simplified as follows [14]:

$$\min J(x) = \left[z - h(x)\right]^T [R^{-1}] \left[z - h(x)\right] \qquad (3.4)$$

To minimize the value of $J(x)$, the first order optimality condition of derivative has to be satisfied. therefore, the derivative of Equation (3.4) can be found as follows:

$$g(x) = \frac{\delta J(x)}{\delta x} = -H^T(x)R^{-1}[z - h(x)] = 0 \tag{3.5}$$

where, $H(x) = \frac{\delta J(x)}{\delta x}$ is known as the Jacobian matrix with the dimension of (mXn).

It is to be mentioned that the Equation (3.5) is only true for the overdetermined systems; the number of parameters to be estimated is less than the number of measurements provided, means $m>n$.

Therefore, to derive the proper Jacobian matrix for the power system, equations of power-injections and power-flows of the buses are needed to be used.

Real and reactive power-injection in bus i is represented by the equations [8], [14]:

$$P_i = V_i \sum_{j \in N_i} V_j (G_{ij} Cos\theta_{ij} + B_{ij} Sin\theta_{ij}) \tag{3.6}$$

$$Q_i = V_i \sum_{j \in N_i} V_j (G_{ij} Sin\theta_{ij} - B_{ij} Cos\theta_{ij}) \tag{3.7}$$

where V_i and Θ_i are the voltage-magnitude and angle of bus i and $\Theta_{ij}=\Theta_i-\Theta_j$.

$G_{ij}+jB_{ij}$ is the ij^{th} element of the complex bus admittance matrix.

N_i is the set of bus numbers which are connected to bus i directly.

However, real and reactive power-flows from bus i to j can be calculated by the equations:

$$P_{ij} = V_i^2 (g_{si} + g_{ij}) - V_i V_j (g_{ij} Cos\theta_{ij} + b_{ij} Sin\theta_{ij}) \tag{3.8}$$

$$Q_{ij} = -V_i^2(b_{si} + b_{ij}) - V_i V_j (g_{ij} Sin\theta_{ij} - b_{ij} Cos\theta_{ij}) \tag{3.9}$$

where, $g_{ij}+jb_{ij}$ is the admittance of the series branch connecting bus i and j.

$g_{si}+jb_{si}$ is the admittance of the shunt branch connected to branch i if the network branch is π modeled.

therefore, the measurement Jacobian for power system is as follows:

$$H = \begin{bmatrix} \frac{\delta P_{inj}}{\delta \theta} & \frac{\delta P_{inj}}{\delta V} \\ \frac{\delta P_{flow}}{\delta \theta} & \frac{\delta P_{flow}}{\delta V} \\ \frac{\delta Q_{inj}}{\delta \theta} & \frac{\delta Q_{inj}}{\delta V} \\ \frac{\delta Q_{flow}}{\delta \theta} & \frac{\delta Q_{flow}}{\delta V} \\ \frac{\delta V}{\delta \theta} & \frac{\delta V}{\delta V} \end{bmatrix} \tag{3.10}$$

The detail expressions for real power-injections are:

$$\frac{\delta P_i}{\delta \theta_i} = \sum_{j=1}^{N} V_i V_j (-G_{ij} Sin\theta_{ij} + B_{ij} Cos\theta_{ij}) - V_i^2 B_{ii} \tag{3.11}$$

$$\frac{\delta P_i}{\delta \theta_j} = V_i V_j (G_{ij} Sin\theta_{ij} - B_{ij} Cos\theta_{ij}) \tag{3.12}$$

$$\frac{\delta P_i}{\delta V_i} = \sum_{j=1}^{N} V_j (G_{ij} Cos\theta_{ij} + B_{ij} Sin\theta_{ij}) + V_i G_{ii} \tag{3.13}$$

$$\frac{\delta P_i}{\delta V_j} = V_i (G_{ij} Cos\theta_{ij} + B_{ij} Sin\theta_{ij}) \tag{3.14}$$

The detail expressions for reactive power-injections are:

$$\frac{\delta Q_i}{\delta \theta_i} = \sum_{j=1}^{N} V_i V_j (G_{ij} Cos\theta_{ij} + B_{ij} Sin\theta_{ij}) - V_i^2 G_{ii} \tag{3.15}$$

$$\frac{\delta Q_i}{\delta \theta_j} = V_i V_j (-G_{ij} Cos\theta_{ij} - B_{ij} Sin\theta_{ij}) \tag{3.16}$$

$$\frac{\delta Q_i}{\delta V_i} = \sum_{j=1}^{N} V_j (G_{ij} Sin\theta_{ij} - B_{ij} Cos\theta_{ij}) - V_i B_{ii} \tag{3.17}$$

$$\frac{\delta Q_i}{\delta V_j} = V_i (G_{ij} \sin\theta_{ij} - B_{ij} Cos\theta_{ij}) \tag{3.18}$$

The detail expressions for real power-flows are:

$$\frac{\delta P_{ij}}{\delta \theta_i} = V_i V_j (g_{ij} Sin\theta_{ij} - b_{ij} Cos\theta_{ij}) \tag{3.19}$$

$$\frac{\delta P_{ij}}{\delta \theta_j} = -V_i V_j (-g_{ij} Sin\theta_{ij} - b_{ij} Cos\theta_{ij}) \tag{3.20}$$

$$\frac{\delta P_{ij}}{\delta V_i} = -V_j (g_{ij} Cos\theta_{ij} + b_{ij} Sin\theta_{ij}) + 2(g_{si} + g_{ij}) V_i \tag{3.21}$$

$$\frac{\delta P_{ij}}{\delta V_j} = -V_i (g_{ij} Cos\theta_{ij} + b_{ij} Sin\theta_{ij}) \tag{3.22}$$

The detail expressions for reactive power-flows are:

$$\frac{\delta Q_{ij}}{\delta \theta_i} = -V_i V_j (g_{ij} Cos\theta_{ij} + b_{ij} Sin\theta_{ij}) \tag{3.23}$$

$$\frac{\delta Q_{ij}}{\delta \theta_j} = V_i V_j (g_{ij} Cos\theta_{ij} + b_{ij} Sin\theta_{ij}) \tag{3.24}$$

$$\frac{\delta Q_{ij}}{\delta V_i} = -V_j (g_{ij} Sin\theta_{ij} - b_{ij} Cos\theta_{ij}) - 2(b_{si} + b_{ij}) V_i \tag{3.25}$$

$$\frac{\delta Q_{ij}}{\delta V_j} = -V_i (g_{ij} Sin\theta_{ij} - b_{ij} Cos\theta_{ij}) \tag{3.26}$$

The elements corresponding to voltage-magnitude measurements are as follows:

$$\frac{\delta V_i}{\delta V_i} = 1,\ \frac{\delta V_i}{\delta V_j} = 0,\ \frac{\delta V_i}{\delta \theta_i} = 0,\ \frac{\delta V_i}{\delta \theta_j} = 0$$

The nonlinear function *h(x)* can be linearized as:

$$h(x + \Delta x) \approx h(x) + H(x)\Delta x \tag{3.27}$$

If *H* is represented as *H(x)*, the following iterative procedure can be obtained:

$$(H^T R^{-1} H)\Delta x = H^T R^{-1}[z - h(x)] \tag{3.28}$$

$$\text{Or, } \Delta x = (H^T R^{-1} H)^{-1} H^T R^{-1}[z - h(x)] \tag{3.29}$$

The symmetric matrix $([H]^T [R]^{-1} [H])$=*G(x)* is called the Gain or information matrix.

Therefore,

$$x_{k+1} = x_k + \Delta x = x_k + \left[[H]^T [R]^{-1} [H] \right]^{-1} [H]^T [R]^{-1} \begin{bmatrix} z_1 - h_1(x_k) \\ z_2 - h_1(x_k) \\ \cdots \\ \cdots \\ z_m - h_m(x_k) \\ \\ \end{bmatrix} \tag{3.30}$$

The equation 3.30 describes the relation between the WLS estimate for incremental change in states and the mismatch between the measured and calculated measurements. Δx is the measurement mismatch, which is the iteration step for next iteration. Iterative procedure terminates when Δx goes below a certain low threshold value, e.g. $1xe - 4$ [40]. There are many factors that can impact the convergence of the Gaussian-Netwon based WLS estimator, such as weights of the measurements, the loading point of the system, bad-data and topology errors, etc. The state estimation convergence much depends on how well the system model fits the data. Several researches has been carried out on the field of convergence criteria and conditions of WLS estimator [8], [14], [83], [84].

3.2 Weighted Least Absolute Value (WLAV)

WLAV is a robust estimator which uses linear programming (LP) approaches (simplex method, interior point method) to solve the linearized problem while estimating the states [85], [86]. WLS has explicit formula for calculation of states, whereas WLAV regression problem does not contain explicit formula. Therefore, in literature, WLAV problem is usually formulated as linear programming first and then solved. WLAV performs much better for bad-data rejection but fails sometimes in case of leverage points [87].

Power system is made of n buses with meters placed at m locations to provide measurement vector z_i of size $(m\ x\ 1)$ to obtain system state vector x of size $(n\ x\ 1)$. e_i of size $(m\ x\ 1)$ is the error induced in the measurements. $h_i(x)$ of size $(m\ x\ 1)$ is the nonlinear function relating system states and measurements.

$$z_i = h_i(x) + e_i, \qquad i = 1, \ldots, m \tag{3.31}$$

WLAV estimator minimizes the objective function [40]:

$$f(x) = \sum_{i=1}^{m} W_i \left| h_i(x) - z_i \right| \tag{3.32}$$

Where W_i represents the applied weight to i^{th}measurement, reciprocal to error variance.

$$w_i = \frac{1}{\sigma_i}, \qquad W = R^{-1},\ 1 \le i \le n$$

The objective function *f(x)* is linear. Therefore, Taylor approximation *h(x)* at point $x_0$is used for the solution.

$$\Delta z = H.\Delta x + e \tag{3.33}$$

$$\Delta z = Z - h(x_0) \tag{3.34}$$

$$H = \left. \frac{\partial h(x)}{\partial x} \right|_{x = x_0} \tag{3.35}$$

$$\Delta x = x - x_0 \tag{3.36}$$

It is assumed that absolute error ($|e_i|$) will be less than a threshold value, ε_i

$$|e_i| \le \varepsilon_i \tag{3.37}$$

The equation (3.37) can be divided into two equations by adding two nonnegative slack variables, l_i and k_i [40], [88].

$$e_i - l_i = -\varepsilon_i \tag{3.38}$$

$$e_i + k_i = \varepsilon_i \tag{3.39}$$

Adding equations (3.38) and (3.39), we get

$$e_i = \frac{l_i - k_i}{2} = u_i - v_i \tag{3.40}$$

Similarly, subtracting equation (3.39) from (3.38), we get

$$\varepsilon_i = u_i + v_i \tag{3.41}$$

$$u_i = \frac{1}{2} l_i \tag{3.42}$$

$$v_i = \frac{1}{2} k_i \tag{3.43}$$

Minimization of ε_i is liked minimizing e_i. Therefore, the objective function $f(x)$ of equation 3.32 can be represented by a new form, $f'(x)$:

$$f'(x) = \sum_{i=1}^{m} W_i |\varepsilon_i| = \sum_{i=1}^{m} W_i (u_i + v_i) \tag{3.44}$$

This objective function $f^{'}(x)$ and the constraint of the WLAV estimator can be optimized using linear programming method. A built-in MATLAB package named "*lp_solve*" has been used in this dissertation to solve the simulation problem of WLAV. The complete algorithm of WLAV is presented in a flow diagram in Figure 3.1:

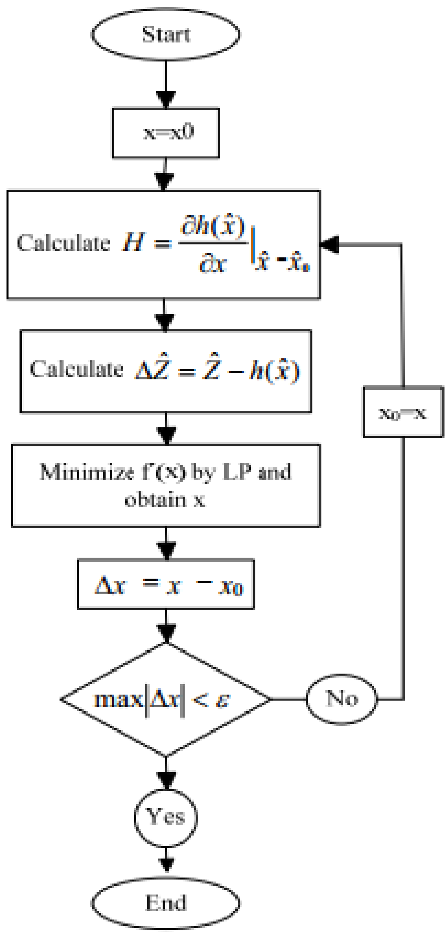

Figure 3.1 Weighted Least Absolute Value (WLAV) Algorithm

3.3 Least Measurement Rejected (LMR)

LMR is a regression based robust estimator, which tries to reduce the number of rejected measurements after assigning a tolerance or uncertainty range to each of the measurement. A positive and negative tolerance range needs to be defined. For example, if we put a tolerance range of 1.5 MW for a power-flow measurement of 103 MW, we can say that the measurement is "good" if the estimated value lies within the range of 101.5MW to 104.5MW. An estimated flow outside this range would imply that the measurement is "suspect" and will get rejected. The phase of measurement elimination will occur in each iteration. The rejected measurements will not take part in estimation process in the next iteration. Therefore, minimization of the number of suspect measurements or maximization of the good estimates is the prime objective in LMR formulation. Therefore, the objective function of LMR is as follows [33]:

$$\min \sum_{i=1}^{n} k_i \tag{3.45}$$

Where k_i is the 0/1 binary variable for measurement *i*.

In LMR, each of the measurements is presented by two inequality constraints depending upon the upper and lower tolerance limits.

$$h_i(x) < z_i + t_i^{+} \tag{3.46}$$

$$h_i(x) > z_i - t_i^{-} \tag{3.47}$$

Where, z_i presents i^{th} measurement,

$h_i(x)$ correspond to a nonlinear function vector which relates measurements z_i to states (x)

t_i^+ is an upper limit obtained from the i^{th} element in vector T added to the i^{th} measurement z_i.

t_i^- is an upper limit obtained from the i^{th} element in vector T added to the i^{th} measurement z_i.

And x is the state vector.

Therefore, when a measurement is found large enough outside the boundary, it is required to ignore or switch off a measurement and the value of k_i becomes 1. For the "good" measurements which are within the tolerance limit, the value of k_i is 0. Thus, the problem formulation could be generalized by adding some 0/1 conditions to be applied whenever needed.

So, the equations (3.46) and (3.47) can be rewritten as:

$$\begin{cases} h_i(x) < z_i + t_i^+ + M\,k_i & (3.48) \\ h_i(x) > z_i - t_i^- - M\,k_i & (3.49) \end{cases}$$

where M is a diagonal matrix of $(p \times p)$ dimension containing arbitrarily large positive scalar values. The value of M has been selected large enough to avoid any kind of influence of rejected measurements on estimation performance.

The above-described objective function and constraints could be solved by any kind of MILP solver, which can deal with mixed integer problems. Therefore, the problem becomes like this [38]:

$$\min\ C^T.Y$$

$$\text{s.t. } A.Y \le B \tag{3.50}$$

Where, inequality constraints of the problem are represented by the following matrices:

$A = \begin{bmatrix} H & -M \\ -H & -M \end{bmatrix}; Y^T = [\Delta x, p]$; H is the Jacobian matrix

And $B = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} b+t \\ b-t \end{bmatrix}; b = \Delta z = z - z_{est}$; Where b is the residue which is calculated from the difference between measurement and estimated values. C^T contains zeros and ones to formulate the MILP problem.

3.4 Inclusion of Current Phasors in Estimation Algorithms

The installation of PMUs in the conventional SCADA based power system improves the performance of the estimator. Once a PMU is placed in a bus, the voltage phasor of that bus and current phasors of all connected lines are available. Therefore, the estimator should be capable to handle the measurements from both SCADA and PMU simultaneously.

The conventional estimators don't have feature of current phasor in the formulation. There are three approaches of current phasor inclusion into a conventional estimator [79]:

1. Current phasor measurement in polar form: magnitude and angle.
2. Current phasor measurement in rectangular form: real and imaginary.
3. Pseudo-voltage measurement with the help of current measurement and known line parameters.

The second method is superior than others in terms of estimation performance and convergence criteria, as concluded in paper [79]. This dissertation has adopted the mentioned process of rectangular format in including current phasors in WLS, WLAV and LMR estimators. Therefore, the Jacobian matrix presented in equation 3.10 needs to be updated with some additional components. The new elements of H will relate between current phasors with state variables.

The typical current flow in a branch can be presented by the equation:

$$I_{i,j} = I_{ij,real} + I_{ij,imag} \tag{3.51}$$

$$I_{ij,real} = (g_{ij} + g_{io})V_i \cos(\theta_i) - g_{ij}V_j \cos(\theta_j) - (b_{ij} + b_{io})V_i \sin(\theta_i) + b_{ij}V_j \sin(\theta_j) \tag{3.52}$$

$$I_{ij,imag} = (g_{ij} + g_{io})V_i \sin(\theta_i) - g_{ij}V_j \sin(\theta_j) - (b_{ij} + b_{io})V_i \cos(\theta_i) + b_{ij}V_j \cos(\theta_j) \tag{3.53}$$

where

$I_{ij,real}$ & $I_{ij,imag}$ are rectangular components (real and imaginary) of the branch current flowing between bus i & j.

V_i, θ_i, V_j & θ_j are voltage magnitude and phase angle of bus i & j,respectively.

g_{ij} & b_{ij} are conductance & susceptance between bus i & j

g_{io} is the shunt conductance of bus i

b_{io} is the susceptance of bus i

Partial derivative of equations (3.52) and (3.3) with respect to state variables (V_i, θ_i, V_j & θ_j) will be incorporated into existing Jacobian. Those can be calculated as follows:

$$\frac{\partial I_{ij,real}}{\partial \theta_i} = -V_i[(g_{ij} + g_{io})\sin(\theta_i) + (b_{ij} + b_{io})\cos(\theta_i)] \tag{3.54}$$

$$\frac{\partial I_{ij,real}}{\partial V_i} = (g_{ij} + g_{io})\cos(\theta_i) - (b_{ij} + b_{io})\sin(\theta_i) \tag{3.55}$$

$$\frac{\partial I_{ij,imag}}{\partial \theta_i} = V_i[(g_{ij} + g_{io})\cos(\theta_i) - (b_{ij} + b_{io})\sin(\theta_i) \tag{3.56}$$

$$\frac{\partial I_{ij,imag}}{\partial V_i} = (g_{ij} + g_{io})\sin(\theta_i) + (b_{ij} + b_{io})\cos(\theta_i) \tag{3.57}$$

$$\frac{\partial I_{ij,real}}{\partial \theta_j} = V_j(g_{ij}\sin(\theta_j) + b_{ij}\cos(\theta_j)) \tag{3.58}$$

$$\frac{\partial I_{ij,real}}{\partial V_j} = -g_{ij}\cos(\theta_j) + b_{ij}\sin(\theta_j) \tag{3.59}$$

$$\frac{\partial I_{ij,imag}}{\partial \theta_j} = V_j(-g_{ij}\cos(\theta_j) + b_{ij}\sin(\theta_j)) \tag{3.60}$$

$$\frac{\partial I_{ij,imag}}{\partial V_j} = -g_{ij}\sin(\theta_j) - b_{ij}\cos(\theta_j) \tag{3.61}$$

The derivative of the phasor elements will be added in the Jacobian matrix of equation (3.10). The modified Jacobian along with the newly added is presented below.

$$H=\begin{bmatrix} \frac{\delta P_{inj}}{\delta\theta} & \frac{\delta P_{inj}}{\delta V} \\ \frac{\delta P_{flow}}{\delta\theta} & \frac{\delta P_{flow}}{\delta V} \\ \frac{\delta Q_{inj}}{\delta\theta} & \frac{\delta Q_{inj}}{\delta V} \\ \frac{\delta Q_{flow}}{\delta\theta} & \frac{\delta Q_{flow}}{\delta V} \\ \frac{\delta V}{\delta\theta} & \frac{\delta V}{\delta V} \\ \frac{\partial I_{F,Real[ij]}}{\partial\theta} & \frac{\partial I_{F,Real[ij]}}{\partial Vm} \\ \frac{\partial I_{F,Imag[ij]}}{\partial\theta} & \frac{\partial I_{F,Imag[ij]}}{\partial Vm} \end{bmatrix} \tag{3.62}$$

The existing state estimators deal with power flows and power injections which are already in rectangular coordinates and therefore, it is easy to incorporate current flows in rectangular coordinates. Practically, PMU provided current measurements are in polar coordinate which are converted into rectangular coordinate before using in the estimation process. The relation between polar & rectangular measurement is given by following equation [40].

$$I_{ij,real} = I_{ij}\cos\theta_{I_{ij}} \tag{3.63}$$

$$I_{ij,imag} = I_{ij}\sin\theta_{I_{ij}} \tag{3.64}$$

The control centers consider the polar values as direct measurement and the rectangular values as indirect. Therefore, the error covariance matrix of direct measurements need to be converted into indirect-rectangular form, like current phasor conversion. The standard deviation of translated measurements can be calculated from following equations [89], [40].

$$\sigma_{I_{ij,real}} = \sqrt{\left(\frac{\partial I_{ij,real}}{\partial I_{ij}}\right)^2 \sigma_{I_{ij}}^2 + \left(\frac{\partial I_{ij,real}}{\partial \theta_{ij}}\right)^2 \sigma_{\theta_{I,ij}}^2} \tag{3.65}$$

$$\sigma_{I_{ij,real}} = \sqrt{\left(\cos\theta_{I_{ij}}\right)^2 \sigma_{I_{ij}}^2 + \left(I_{ij}\sin\theta_{I_{ij}}\right)^2 \sigma_{\theta_{I,ij}}^2} \tag{3.66}$$

$$\sigma_{I_{ij,imag}} = \sqrt{\left(\frac{\partial I_{ij,imag}}{\partial I_{ij}}\right)^2 \sigma_{I_{ij}}^2 + \left(\frac{\partial I_{ij,imag}}{\partial \theta_{ij}}\right)^2 \sigma_{\theta_{I,ij}}^2} \tag{3.67}$$

$$\sigma_{I_{ij,imag}} = \sqrt{\left(\sin\theta_{I_{ij}}\right)^2 \sigma_{I_{ij}}^2 + \left(I_{ij}\cos\theta_{I_{ij}}\right)^2 \sigma_{\theta_{I,ij}}^2} \tag{3.68}$$

where $\sigma_{I_{ij,real}}$ & $\sigma_{I_{ij,imag}}$ are standard deviation of real and imaginary parts of current flows respectively.

3.5 Aspects of Tolerance Selection in LMR Estimator

The formulation of mostly used estimator weighted least square (WLS) [14] is having a term called weight (*W*) which is the reciprocal of the variance of the meter. By *W*, the weight is applied to each meter reading depending upon its accuracy. If the meter is very accurate like phasor measurement units (PMU) [90], the value of *W* is considered as very high to make sure that the accurate measurement takes part in the estimation and improves the performance.

The role of tolerance (*T*) in LMR is similar to the role of *W* in WLS. Because, the value of *T* plays the key role of rejecting the measurements from the estimation process and it is logically desired that the 'better' measurements will take part in estimation process after the phase of rejection. A slight variation in the value of *T* results a notable change in LMR performance sometimes.

LMR tries to reduce the number of rejected measurements (those are out of the provided limit) in each iteration and the non-rejected measurements take part in the regression process at last to estimate the states of the power system. As seen from the formulation of LMR, tolerance of a measurement (*t*) is further divided into two parts: upper limit t_i^+ and lower limit t_i^-. It means that by choosing the tolerance, an allowable range between upper and lower limit is provided for the specific meter measurement. The estimated value of a measurement tries to reach inside the tolerance limit where failure will result the rejection of that measurement. Thus, the process of eliminating the 'unfit' measurements will carry on until the stopping criteria is achieved. Therefore, selecting the value of the tolerance limit plays a key role to decide whether the measurement should be rejected or not.

A) Impact of High Tolerance Value

If a high value of tolerance is applied to all the measurements, it will generate a wide tolerable range around each measurement. Thus, the probability of rejection will become very low. Figure 3.2 demonstrates such a case.

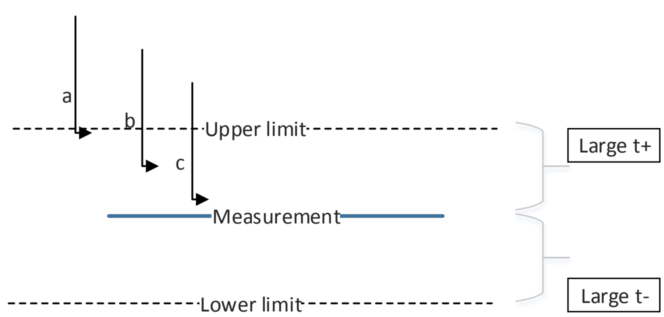

Figure 3.2 Impact of high tolerance values on LMR

Points a, b, and c are representing three probable estimated solutions where c is the closest one to measurement. Because of the wider range, all of the possible estimates will result the ‘non-rejection’ of the measurement. Therefore, even if the measurement is bad, so as the estimated value (a), it will not be rejected. Thus, the estimation performance will fall even though the number of rejected measurements could be very small.

B) Impact of Low Tolerance value

If a low value of tolerance is applied to all the measurements, it will generate a narrow tolerable range around the measurements. Thus, the probability of rejection will become very high. Figure 3.3 demonstrates a case of low tolerance.

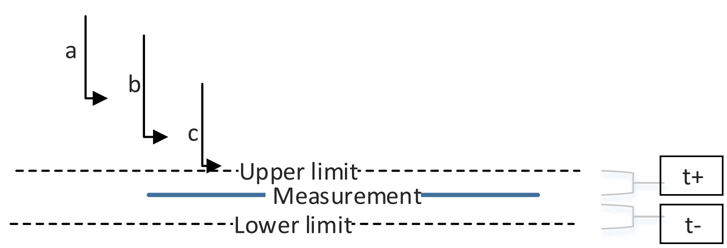

Figure 3.3 Impact of low tolerance values on LMR

Because of the narrower range, all the possible estimates (points a, b, c) will result the ‘rejection’ of the measurement. Therefore, even if the measurement is good, so as the estimated value (c), it will be rejected from the estimation. Thus, the estimation performance will fall and the number of rejected measurements will be very high.

Therefore, applying a fixed tolerance value to all the measurements, which is adopted by most of the works on LMR, is not a feasible solution. Consequently, it is difficult to judge which value of tolerance should be considered as ‘low’ and which one should be ‘high’.

The dissertation has come with the unique idea that the tolerance shouldn’t be same for all the measurements and should depend upon the accuracy of the meter. If the quality of the meter is good, the tolerance could be selected as a very small value. This will ensure that the estimated value will follow the given measurement. On the other hand, if the meter reading is less accurate, an appropriate tolerance value must be carefully selected.

The main features of tolerance value selection in LMR are presented below:

- During estimation process with LMR, an estimated value tries to fit itself within the tolerable range provided to the corresponding measurement. The failure will result in rejecting that measurement from the regression process.
- A rejected measurement in LMR does not always mean that the measurement is an outlier. Measurements, not suited for the estimation will get eliminated and the rest of the measurements will take part in the regression process.
- Selection of higher tolerance range may result in rejecting small number of measurements. This could affect the estimation performance badly when large number of bad-data are presented simultaneously.
- Selection of lower tolerance range may result in rejecting high number of measurements. This could affect the observability of the system.
- T could be as low as zero but needs to be applied carefully to highly reliable measurement meters only. This will ensure that the estimated value follow the corresponding measurement effectively.

A unique strategy of tolerance value selection is proposed in this dissertation which imposes lower tolerance values to the ‘best’ measurement meters. An initial step of estimation is carried out (under normal noise condition) in order to extract the “best” measurement meter

This can be achieved by selecting the meters that has the lowest tolerance between the estimated and measured values. The selected “best” meters must comply with the observability of the system and the selection process could be performed only once. Once these tolerances are properly selected, they will be used with the LMR estimator on a regular basis as any robust estimator.

However, two robust estimators are proposed based on the newly proposed tolerance selection process and are discussed in the following chapters.

3.6 Proposed Hybrid Least Measurement Rejected (HLMR) Estimator

Based on the concept of tolerance value selection, two robust estimators are developed in this dissertation. One of them is formed by the hybridization of WLS and LMR. This estimator is developed for those electric utilites that are already using WLS in their EMS. The proposed HLMR estimator uses WLS in the initial estimation process to select the proper tolerance values for LMR estimator. This initial step with WLS is performed only once in order to drive the appropriate “*T*” value. If there is a major change in the configuration of the system, such as addition of new bus(s), or removal of existing bus(s), then the initialization step needs to be repeated. The following explains the major steps of HLMR estimator:

a) Finding Initial Tolerance (T_{ini}) Using WLS:

In this step, SCADA meter measurements mixed with white noise are used as input to the WLS estimator to run the initial estimation process. The purpose of using WLS is to get the estimated values and to select the initial tolerances for each meter.

The estimated values of WLS are used to find out the difference between estimated and measured values. Thus, each of the meter reading is assigned with a unique and new tolerance, which is equal to the corresponding (|*Estimated-Measurement*|) value. This is considered as the initial tolerance (T_{ini}) for the meters. Value of initial tolerance reflects the accuracy of the meter reading. The lower value of T_{ini} reflects the better accuracy of the meter and vice versa.

WLS is chosen for initial estimation because of the following reasons:

- The capability of WLS in providing accurate estimation under the presence of white noise only.
- Most of the current-day power systems are installed with WLS.

The accuracy of i^{th} meter measurement is ($|Actual_i\text{-}Measurement_i|$) which is almost identical to the value of ($|Estimated_i\text{-}Measurement_i|$), if the estimation is efficient. Therefore, the estimated values of WLS are considered as the true-values of the states in the process of deciding the accuracy of the meters.

b) Sorting the Measurements:

In this step, the available measurements will be sorted according to their corresponding values of initial tolerance in a descendent way. The purpose of the sorting is to identify the 'best' meter locations in terms of accuracy. Let the total number of available measurements be "*p*". Select the "*q*" number of measurements in accordance with the following conditions:

- *q* is equal to *(2N-1)* where *N* is the number of buses present in the system. The selected number of measurements must make the system observable.

- The q measurements should be among the lowest corresponding (|*Estimated-Measurement*|) values.

c) Selecting Final Tolerance (T_{final}):

At this step, the tolerance of the q meters in step '**b**' is forced to zero. This enforcement is done since the selected q meters are the best among the p available meters. The remaining meters will keep the initial tolerance (T_{ini}) as obtained in step '**a**'. Both the revised tolerances for q and remaining p-q measurements are referred to the final tolerance vector, T_{final}.

T_{final} has a dimension of $(p \times 1)$ which contains all the revised tolerances for each meter readings.

d) Final Estimation With LMR:

The selected new tolerances (T_{final}) are used in the final stage of the estimation process using LMR estimator as shown in Chapter 3.3.
As the measurements are now having the properly chosen tolerance, the 'best' measurements will have the least possibility to be rejected. Thus, the appropriate measurement values will be carefully chosen for regression and that will ensure the better estimation of the states.

For a specific meter arrangement of the power system, steps '*a-c*' should be done only once. Whenever a change is made in the meter arrangement due to adding/removal of a bus, steps '*a-c*' need to be repeated to get a revised T_{final}. This will make the proposed estimator time efficient and convenient to use.

The iteration for LMR estimator stops when the number of rejected measurements (β) doesn't change for two consecutive iterations.

Figure 3.4 presents the HLMR estimator with a detail flow diagram:

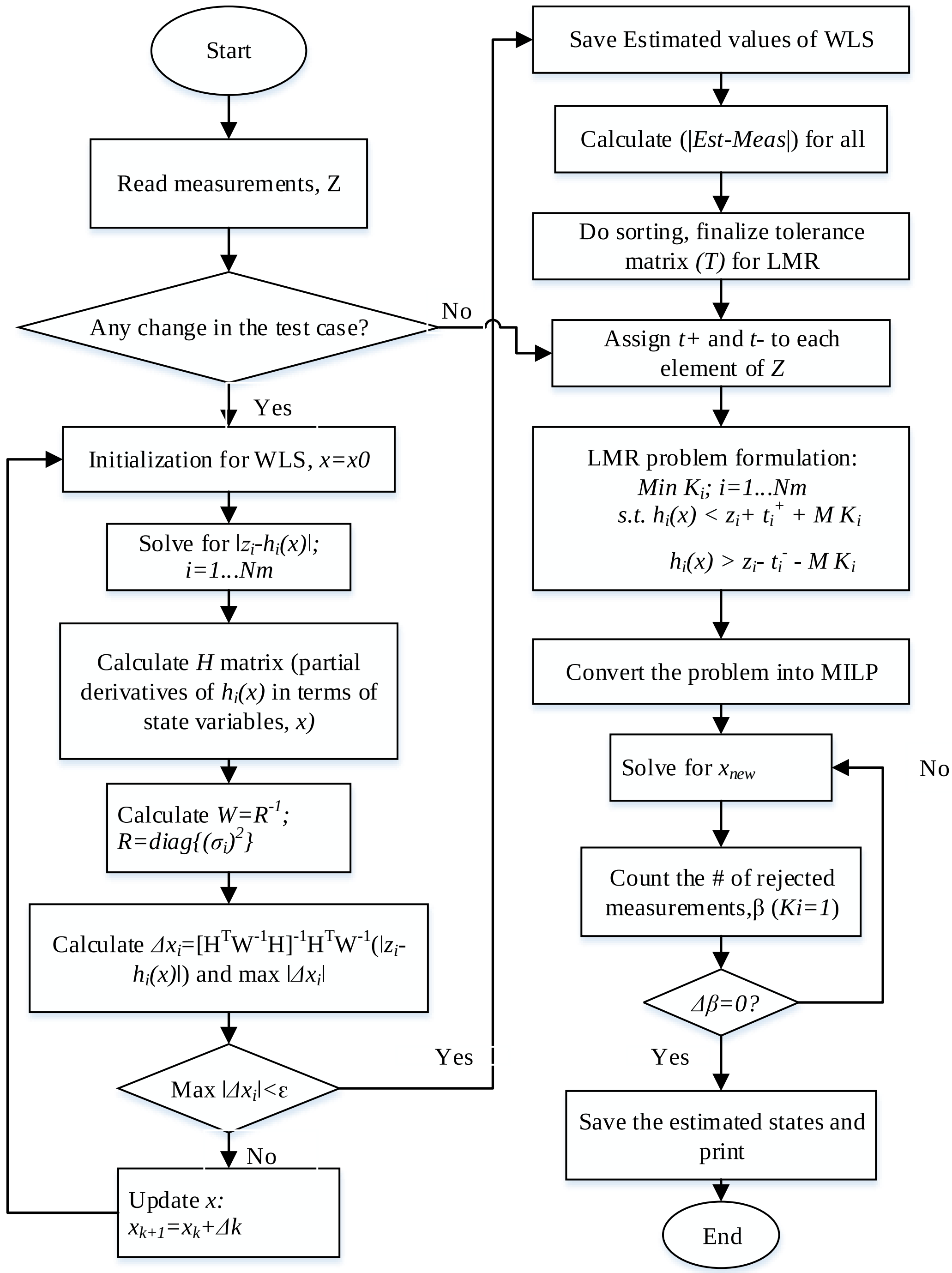

Figure 3.4 Flow Diagram for HLMR Estimator

3.7 Proposed Updated Least Measurement Rejected (ULMR) Estimator

An updated version of LMR is proposed in the dissertation which uses a new approach of tolerance value selection. It is a stand-alone estimator which is robust in nature and doesn't require any post-processing feature to eliminate the bad measurements from the estimation process. Therefore, ULMR is developed for the electric utility if it intends to install a new robust estimator. Different steps of the proposed estimator are presented below:

a) **Initial Estimation Using Initial Tolerance (T_{ini}):**

In this step, SCADA meter measurements mixed with white noise are used as input to the initial estimation process. In selecting the tolerance (T_{ini}) for initial estimation, idea of the sensitivity of meter types is used. Minimum values are given to voltage-magnitude meter readings to ensure the maximum probability of participation during estimation work. Power-flows will have maximum value and the injections in between. All meters of a same type are having equal values of T_{ini}.

The accuracy of i^{th} meter measurement is ($|Actual_i\text{-}Measurement_i|$) which is almost identical to the value of ($|Estimated_i\text{-}Measurement_i|$), if the estimation is efficient. Therefore, the estimated values of initial estimation are considered as the true-values of the states in the process of deciding the accuracy of the meters.

b) **Finding Intermediate Tolerance (T_{inter}):**

The estimated values of initial estimation are used to find out the difference between estimated and measured values. Thus, each of the meter reading is assigned with a unique and new tolerance, which is equal to the corresponding ($|Estimated\text{-}Measurement|$) value.

This is considered as the intermediate tolerance (T_{inter}) for the meters. Value of initial tolerance reflects the accuracy of the meter reading. The lower value of T_{inter} reflects the better accuracy of the meter and vice versa.

c) **Sorting the Measurements:**

In this step, the available measurements will be sorted according to their corresponding values of initial tolerance in a descendent way. The purpose of the sorting is to identify the 'best' meter locations in terms of accuracy. Let the total number of available measurements be "*p*". Select the "*q*" number of measurements in accordance with the following conditions:

- *q* is equal to *(2N-1)* where *N* is the number of buses present in the system. The selected number of measurements must make the system observable.
- The *q* measurements should be among the lowest corresponding (|*Estimated-Measurement*|) values.

d) **Selecting New Tolerance (T_{new}):**

At this step, the tolerance of the *q* meters in step '**c**' is forced to zero. This enforcement is done since the selected *q* meters are the best among the *p* available meters. The remaining meters will keep the intermediate tolerance (T_{inter}) as obtained in step '**b**'. Both the revised tolerances for *q* and remaining *p-q* measurements are referred to the final tolerance vector, T_{final}.

T_{final} has a dimension of $(p \times 1)$ which contains all the revised tolerances for each meter readings.

e) **Final Estimation:**

After the proper selection of the tolerance values, final estimation will be carried out with T_{new}. The problem formulation of this stage is same as described in chapter 3.3. Only the difference is in the values of the tolerance. The updated new values of tolerances (T_{new}) will be used in this step. Equations (3.47) and (3.48) are updated as,

$$h_i(x) - Mk_i < Z_i + t^+_{new_i} \tag{3.69}$$

$$h_i(x) - Mk_i < Z_i + t^-_{new_i} \tag{3.70}$$

$t^+_{final_i}$ is an element of vector T_{final} which is added with i^{th} measurement.

Similarly, tolerance $t^-_{final_i}$ is subtracted from i^{th} measurement.

The described objective function and constraint is then converted into mixed integer linear program problem formulation and solved by any kind of solver to get the estimation solutions.

For a specific meter arrangement of the power system, steps (*a-c)* should be done only once. Whenever a change is made in the meter arrangement, process of initial estimation, sorting and determination of T_{new} (steps *a-c*) will be repeated only once to get revised T_{new}.

It is important to mention that the initial estimation and the selection of final tolerance (T_{new}) will be done once for a specific setup of meter arrangement. Unless the meter arrangement is changed, LMR will keep using this tolerance for the estimation. This will make the proposed estimator time efficient and easy to implement.

The whole procedure of tolerance selection for updated LMR is summarized below in short for clear understanding:

Step-01: Analyzing the test case

Step-02: If there's any change in the test case, go to step-03 otherwise go to step-08.

Step-03: Initial estimation with initial tolerance (T_{ini}).

Step-04: Finding out T_{inter} = (|Estimatedi-Measurementi|) value for all measurements.

Step-05: Selecting *(2N-1)* number of measurements with lowest T_{inter}.

Step-06: Select new tolerance (T_{new}) equals to zero for the selected measurements of Step-05.

Step-07: T_{new} of the remaining locations will be same as the value of $T_{inter.}$

Step-08: Use the T_{new} to do the final estimation.

The process of tolerance value selection is almost identical for both the proposed estimators: HLMR and ULMR. However, the ULMR is a standalone robust estimator and it is recommended to install it in the power systems where no estimator is installed. However, HLMR is proposed for the power systems, which are already installed with WLS estimator. The HLMR could be a better replacement of the conventional estimator WLS, along with a separate post processing feature.

3.8 Some Important Aspects of State Estimation

3.8.1 Observability Analysis in Estimation Process

A system is said to be observable by a set of measurements when those measurements can build a full rank spanning tree of the system and are well enough to calculate the state variables. For performing the state estimation process, it is required to ensure the system observability. For an unobservable power system, different observable islands are identified first and minimum number of measurements which can make the entire network observable are found next. Observability depends upon the number and geographical location of the meters in the network. Different aspects of observability analysis is discussed in [91].

The observability analysis of a power system can be done in two ways: topological and numerical.

Topological Observability Analysis: This analysis [56] focuses on building a spanning tree of full rank. In such a case, topological graphs are used to represent the power system with *'N'* number of network buses and *'E'* number of branches between the buses.

An observable island is a region of the network all branch flows can be calculated from the available measurements. In the planning step, an observable island is built first and some other measurements are added next according to some criteria [92]. Topological algorithm analyzes the observability only based on the connection between the buses. The steps to execute the algorithm are as follows:

1. Place meters in the buses which are having only one connected branch.

2. Keep eliminating the buses which are installed with meters and the branches connected to those.
3. Perform step 1 and 2 iteratively until no bus and no branch is left to be eliminated. Minimum number of meters for an observable system will be obtained.
4. Considering the global redundancy, local redundancy and historical values, put additional meters for power-flow and injection.

2.2.2 Numerical Observability Analysis:

A system is numerically observable if the Gain matrix *[G]* is non-singular i.e the Jacobian matrix *[H]* is full-rank.

To demonstrate the process, let us assume a power system is having N number of buses. The diagonal components of the Gain matrix, related with voltage angle and voltage-magnitude are G_θ and G_V, respectively. The subscripts P and Q refer to active and reactive power equations, respectively. Therefore, the system will be P-θ numerically observable if the rank of G_θ is *"N-1"*. Besides, the system is said to be Q-V numerically observable if the rank of G_θ is *"N"* [93].

3.8.2 Redundancy Level for SE

Redundancy level of the power system plays an important role in the performance of state estimation. Redundancy refers to the idea of having extra measurements than the minimum number of measurements to make the system observable. A system, which is poorly redundant results bad estimation of states. Each measurement can be represented by a specific level of redundancy which reflects the availability of the meters around it. This is known as local redundancy. Higher value of local redundancy for a measurement reflects that the location is surrounded by some more meters. The redundancy can be classified in three levels:

- First level can be referred to the state where reduction of measurement will not affect the observability or reliability of the system but will have some negative impact on estimation performance.
- In the second level, loss of measurement will directly affect the reliability of the estimation and some redundant measurements might turn into critical.
- Third level of redundancy reflects the state of very poor redundancy where most of the measurements are in critical state and the reduction of the measurement will make the system unobservable.

As the presence of bad-data is very common in the field of state estimation, it is very essential to ensure a reasonable level of redundancy of the system. First level of redundancy ensures the less impact of bad-data in estimation performance [94]. There it is followed by most of the present-day power systems.

There are two types of meter redundancy: global and local. Global redundancy is the measure of the overall redundant situation of a system. It reflects the overall redundancy picture of the system with available number of measurements and is calculated by following formula: $Global\ redundancy = \frac{N_{meas}}{2N-1}$.

where N_{meas} is the number of available measurements and N is the number of buses in the power system. The minimum value of global redundancy could be 1 which ensures the system observability but represents a third level of redundancy with all critical measurements. Therefore, the minimum number of measurements to ensure the observability can be found by: $N_{meas} = 2N - 1$

Local redundancy refers to each of the individual measurement and reflects how much redundant it is. Local redundancy of the meter readings could be calculated as follows [95]:

$$LR(i) = N_{meas} - \sum_{j=1}^{N_{meas}} r(i, j) \tag{3.71}$$

where,

$$\begin{cases} r(i, j) = 1 \qquad if \quad abs(K(i,i) / K(i, j)) \geq d \\ r(i, j) = 0 \quad otherwise \\ 1 \leq i, \; j \leq N_{meas} \end{cases} \tag{3.72}$$

LR(i) is the local redundancy of i^{th} measurement and *r(i,j)* is a binary entry. The relation between i^{th} measurement with j^{th} measurement is denoted by *K(i,j).* If the diagonal entry [*K(i,i)*] of *K* matrix is larger than off-diagonal element [*K(i,j)*] by a large margin, then the local redundancy of that specific meter is week [14], [96]. The constant *d* is a pre-defined large number and comparison of $abs(K(i,i) / K(i, j))$ with *d* will reflect the redundancy of that particular measurement [95].

The i^{th} bus of a power system will be observable if it fulfills the following condition:

$1 \leq LR(i) \leq N_{meas}$

Therefore, the PMU placement in a power system should emphasize on the improvement of the redundancy as well as the estimation efficiency. A poorly redundant power system with conventional SCADA meters could be upgraded to a very efficient one by installing some PMU meters and in the proper locations [95].

3.8.3 Impact of Critical Measurements

Any measurement can be identified as a redundant or a critical measurement. Critical measurements are those which if removed from the measurements series, will make the system unobservable. The critical set refers to the set of measurements, where removal of one will make others critical. When a critical measurement is removed from the test-case, rank of the Jacobian matrix *[H]* reduces. And the row of *[H]* corresponding to critical measurement becomes linearly independent with the other rows.

Any measurement (i) will be considered as critical if the value of residual is zero [94], [97]:

$$r(i) = z(i) - z\_est(i) = 0 \tag{3.73}$$

$$\sigma(i) = \sqrt{E(i,i)} = 0 \tag{3.74}$$

where $r(i)$ is the residual of i^{th} measurement which is the difference between measurement $z(i)$ and the estimated value $z\_est(i)$.

$\sigma(i)$ is the standard deviation of the i^{th} component of residual vector and E is the residual covariance matrix which can be calculated by:

$$E = R - HG^{-1}H^{T} \tag{3.75}$$

where R is the diagonal covariance matrix and G is the gain matrix.

Critical Set consists of non-critical measurements which are strongly correlated. In a critical set, the normalized residuals of the elements will be equal and the ratio will be 1.

If the normalized residue of i^{th} and j^{th} measurement is $r_N(i)$ and $r_N(j)$, respectively, they will be the member of critical set if:

$$\frac{r_N(i)}{r_N(j)} = 1 \tag{3.76}$$

Removal of any of the measurements *i* or *j* will make the other one critical. The concept of critical measurement should be carefully considered while placing the extra PMUs in the power system. PMU locations should be selected in such a way that it should cover the critical locations. Presence of bad-data in the critical locations will hamper the estimation performance badly even after the installation of extra PMUs in the power system. Therefore, in PMU placement optimization, critical locations should get the priority to be installed with new PMU meters which negate the negative impact of bad-data.

3.8.4 Correlation Between the Measurements

The correlation between the measurements is a vital aspect in state estimation analysis. The condition of whether the measurements are strongly or weakly correlated with each other is having a strong impact on estimation performance. If two of the measurements are strongly correlated, then error in one of them will affect the estimation of the second one badly. Similarly, estimation of weakly correlated measurements are not significantly affected by each other. Sometimes, the measurement errors could be conforming to each other which means that they always appear together [14].

Measurements, having strong correlation between them are called interacting. It is important to find that the multiple number of bad-data affecting the estimator are interacting or not. A well designed robust estimator should withstand with both interacting and non-interacting types of bad-data. Therefore, to ensure the robustness of an estimator, both the interacting and non-interacting multiple bad-data should be applied to check whether the estimator performance breaks down or not.

Residual sensitivity matrix *(S)* can be used to identify whether the measurements are interacting or not. *S* could be calculated as:

$$K = HG^{-1}H^{T}R^{-1} \tag{3.77}$$

$$S = I - K \tag{3.78}$$

S is a matrix with a specific value for each pair of measurement. If S_{ij} is larger than a pre-defined threshold value, then i & j measurements will be interacting to each other [14].

3.8.5 Impact of Bad-data in State Estimation Process

Bad-data is a measurement which is recorded wrong and is very far from its true value. Because of the wrongly taken measurements, sometimes the acquired estimation results a value far away from the true value. Bad-data may occur for many reasons like broken instruments, large noise, bad connection between control centers and measurement devices, wrong wiring, inaccurate calibration of transducers etc. The estimation process should detect and filter out these bad-data as it hampers the estimation performance badly [14].

The number of bad-data present in a measurement series could be single or multiple. Usually single bad-data is present in comparatively small system and multiple in large systems. The correlation between the bad measurements is very important when they are multiple in number. Strongly correlated measurements highly affect the estimation performance and will cause a huge amount of error [98].

There are two ways to deal with bad-data in estimation process [87]: applying post-processing method or using robust estimator. The mostly used weighted least square (WLS) algorithm can't deal with bad-data rather a separate step of post-processing is needed to do that. This process ensures accuracy but with the cost of time. Several robust estimators are proposed in literature which can deal with bad-data during estimation process. An efficient robust estimator must be able to detect the bad-data, identify the location and eliminate.

If there is a bad-data in measurement set, the residual (difference between the measurement and estimated value) will be higher. Chi-Square is a statistical approach of hypothesis testing to detect bad-data. Another more famous and reliable technique for bad-data detection is normalized residual method. It has been found that the largest normalized residual corresponds to a bad measurement [99]. This fact has been successfully used to identify single bad-data but not applicable to identify multiple bad-data. For multiple bad-data occurrence, calculation of residuals and detection of bad-data need to be carried out sequentially unless all the bad-data is identified.

Another very important aspect of bad-data is that the presence of it might make the system unobservable [98]. An element in measurement set could be either redundant (removal does not make system unobservable) or critical (removal make system unobservable). Bad-data on critical measurement is undetectable and will lead the system to be unobservable. PMU inclusion in the measurement series could be an effective solution if it covers the critical measurements and thus negate the impact of bad-data [100].

CHAPTER 4

OPTIMIZATION OF PMU PLACEMENT USING GENETIC ALGORITHM (GA)

This chapter presents one of the major contributions of the dissertation: strategy of optimal PMU placement. Genetic algorithm is used to solve the optimization problem which aims to find the optimal location of any limited number of PMUs that ensures the maximum estimation accuracy. Both the optimization problem formulation and the solution strategy are discussed in steps. Besides, the chapter talks about the significance of covering the critical measurements while placing PMUs. The developed optimization technique minimizes the effect of bad-data appearance by placing PMUs in the critical locations of the power system. A heuristic approach of PMU placement is also addressed in this chapter which has a similar objective and used for the comparison purpose.

4.1 Importance and Application Fields of Phasor Measurement Unit

PMUs are the most efficient and accurate measuring devices used in the power industry. Global positioning system (GPS) has synchronized the real-time PMU meter readings from different points of the power grid. In the power systems, PMUs can be used as a dedicated device, or as a part of a relay system or in a state estimation process. The complexity of the power system networks has been increased significantly in the recent years where the power flow is not only unidirectional from generating stations to consumers but also the utilities are inclining towards participating the grid. Therefore, the grid system must be covered under precise observation to ensure the security and robustness. The time synchronized measurements from PMUs, which are refreshed 120 times per second with very high accuracy, play a key role in the monitoring of modern power industry.

Some of the major application fields of PMU are as follows:

1. Automation of the power system, especially in smart grid.
2. Fault detection of the power system to improve the reliability.
3. Load control technique like demand response of the power system by directing power towards required location in real-time.
4. State estimation process of the power system for wide area monitoring system (WAMS) and control.
5. Detection and classification of the events like switching, tap changing, faults occurring etc.
6. Improvement of the security system through synchronized encryptions and supporting the cyber-attack recognition system.
7. Improvement of power quality by automatic correction and precise analysis of sources.
8. Improvement of the power system control by excitation system, FACTS devices, HVDC networks etc.
9. Instability prediction of the power system and stability analysis.

Bonneville power administration (BPA) was the first utility to use PMU meters in WAMS. Total of 48 PMUs were installed in New York to improve the power system security after the 2003 blackout which affected a huge portion of United States and Canada. In the year

2006, China installed about 300 PMUs to improve its WAMS facility. Similarly, many countries with modern power system are inclining towards installing PMUs because of the wide range of applications.

4.2 Genetic Algorithm (GA)

The genetic algorithm (GA) is an intelligent exploitation search algorithm based on the evolutionary concepts of natural selection and genetics. GA, as a part of evolutionary computing, mimics the idea of Darwin's "survival of the fittest" in reaching a global solution in an optimization problem. It was first proposed and implemented by John Holland and his colleagues from the University of Michigan in between 1960s and 1970s.

GA moves from one population to another to search a global solution of a given problem. Generation of each new population is done by natural selection process which is inspired by the genetic operators like crossover and mutation. Each of the population of GA is known as chromosome which consists of genes. Genes are made of binary bits (0/1). Based on the fitness value, the string of such binary bit search for global optima within a search space. The following three operators do the main job of searching in GA [101], [102].

1. The **selection** operator selects the chromosomes for reproduction from a set of randomly generated population. The fitness values of the chromosome play the vital role in the selection process. The better fit chromosomes are selected as parents and assigned the new job of generating the children.
2. The **crossover** generates a random location within the parent chromosome's string and the genes will be exchanged before and after that point to generate the off-springs /children. The probability of crossover occurrence is usually selected high.

Crossover can be done in multiple points if the size of the string is larger. A double of point crossover is presented in the Figure 4.1 below.

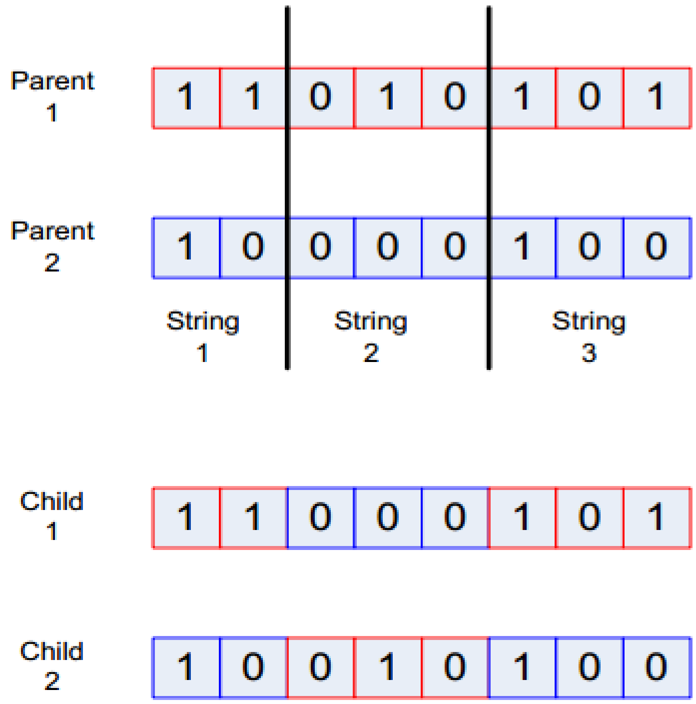

Figure 4.1 Double point crossover in GA

3. **Mutation** phase of GA randomly flips some of the binary bit from in a chromosome. It can be occurred in each bit position in a string depending upon the probability assigned. Usually the probability of occurring mutation is very low and it is not an obvious part of GA to reach the optimal solution.

A mutation process is presented in Figure 4.2 below.

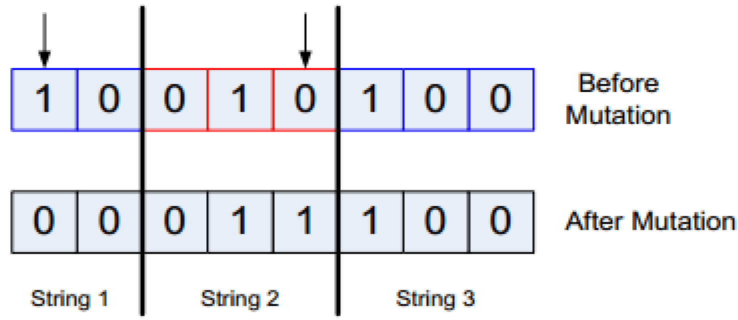

Figure 4.2 Mutation phase of GA

Thus, the operators of GA search for the best fit population within each iteration. Selection of population size and iteration number plays a vital role on the success of GA in reaching the global optima.

4.3 Optimization Problem Formulation for PMU Placement

The objective of the optimization problem is to find the optimal locations for any limited number of PMUs to ensure the best estimation performance. The number of PMU locations to optimize could be any number within the range of available bus locations. This is not a problem like minimizing or maximizing an objective function rather to find out the appropriate locations for the intended number of PMUs to install in a power system that ensures the minimum estimation error [80].

Therefore, the problem formulation could be stated as follows:

Let, the set for available bus locations is denoted as X.

Therefore, $(x_1, x_2, ...x_n) \in X$ and n is the largest bus number.

X_{PMU} is the set of bus locations installed with PMUs in the SCADA-based power system.

X_{opt} is the set of optimal PMU locations. The installation of PMUs in X_{opt} locations will ensure the maximum estimation efficiency. x_{opt} is an individual bus location in the optimal solution set, X_{opt}. The proposed optimization problem uses genetic algorithm to find out X_{opt}.

A_i and E_i are the actual true values and the estimated values of the state variables. Absolute difference between them reflects the error of the estimation process.

r is the reference/slack bus where s represents the buses that covers the critical measurements.

Z is the measurement vector used by the state estimator. Z_{PMU} contains the measurements which are coming from PMUs.

The objective function and the constraints of the optimization problem are as follows:

$$Min \ \left(\frac{1}{2\times n}\sum_{i=1}^{n}\ \sum_{X_{opt}=X_{PMU}}^{X_{opt}\subset X}\ \sum_{Z_{PMU}\subset Z}\left(\left|A_i - E_i\right|\right)\right)$$

$$\begin{aligned} s.t.\ \ & r \in X_{opt} \\ & x_1 \le x_{opt} \le x_n \\ & s \in X_{opt} \end{aligned}$$

The optimization problem searches for the X_{opt} set by minimizing the value of $\left|A_i - E_i\right|$. The optimal solution X_{opt} is a subset of X and contains the same elements as X_{PMU} to ensure that the buses to be installed with PMUs are the optimal solutions. The constraints ensure that the slack bus (s) and the buses (r) who covers the critical zones will be the element of optimal set, X_{opt}. Installed PMU in the slack bus will ensure the accurate phase angle of the reference which will be compared with the remaining bus-angles. covering the critical locations by PMUs will ensure the least effect of bad-data occurrence on state estimation performance.

The optimization process ensures that the PMU measurements (Z_{PMU}) are included in the overall measurement series (Z) during estimation process.

One of the significance of the proposed optimization method is that, the error indicator is applicable for measuring the accuracy of any estimator even though different estimators have different objective functions and problem formulations. Therefore, the optimization problem could be implemented and tested with any estimation algorithm without modifying the problem formulation and solution strategy.

s represents the buses that covers the critical measurements of the given measurement set. Before placing the PMUs, if the SCADA meter measurement set is having three critical measurements as P_{i-j}, Q_{i-j} and P_i, then bus i will be considered as the member of subset, s which must be chosen in the optimal solution set, X_{PMU}.

x_1 and x_n are the minimum and maximum bus locations to be considered in optimization problem. For a 30-bus power system, the values for x_1 and x_n will be 1 and 30 respectively

4.4 Significance of Covering the Critical Zones by PMUs

It has been discussed in chapters 2.2 and 2.3 that the redundancy of meters plays a vital role in the monitoring of a power network. Due to the meter-arrangement in a power system, some measurements become critical. Even a power system with substantial number of installed meters could have some critical measurements for not organizing the meters properly. A critical measurement is that, which if removed from the test case, will make the entire system unobservable [103]. It is the extreme level of low-redundancy of a measurement. Presence of critical measurement in a test case puts the system security in risk. Therefore, proper placement of the meters is a vital part of the energy management system.

Bad-data occurrence is a common phenomenon in the study of state estimation. However, the bad-data could come from any location of the system. If the bad-data occurs in a redundant location of the system, it will not hamper the estimation performance much. Consequently, a bad-data occurrence from a low-redundant location will affect the estimation badly. However, if a bad-data is among the critical measurements, it is not possible to detect that and will affect the estimation performance badly [14]. Therefore, identifying the critical measurements and making them redundant should be a vital task in improving the performance of estimation process.

The dissertation presents a PMU placement strategy which considers the covering of critical measurements in a power system. Before going into the main loop of GA, the elitism strategy is defined which forces the optimization process to cover some of the buses with PMUs. As described in chapter 4.2, the bus that covers the critical zone needs to be equipped with PMUs by proper implementation of elitism strategy. Figure 4.3 shows how the elitism strategy is set before going to the main process of optimization by BGA.

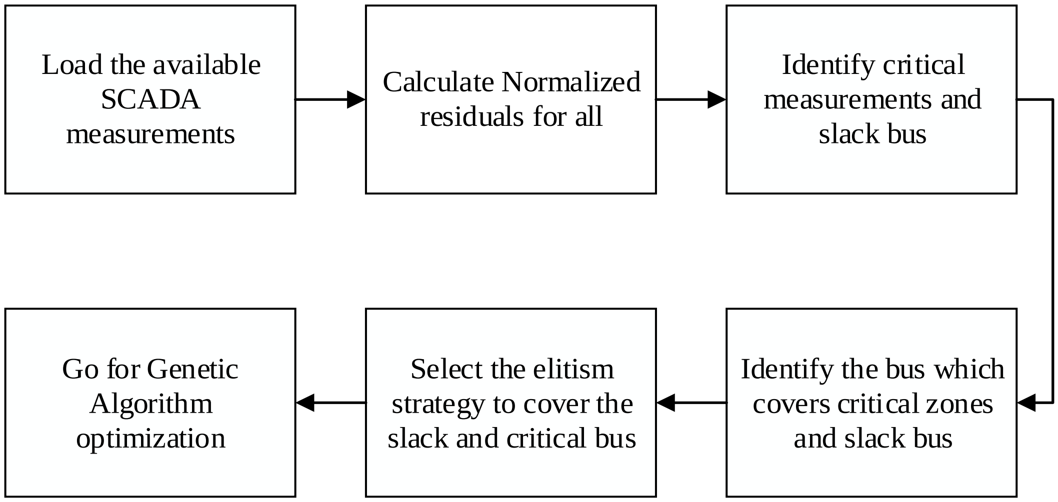

Figure 4.3 Flow diagram of Optimization procedure [80]

It is seen that the available measurement system is loaded at the beginning of the process. Before going into the main loop of genetic algorithm, residuals for all the measurements are calculated. Thus, the critical measurements as well as the buses which covers those measurements are identified. However, the slack bus of the power system is identified too. Therefore, an elitism strategy is set in the initialization stage of GA which ensures that the slack bus and the bus(es) to cover the critical measurements will be installed with PMUs.

4.5 Solution Strategy of the Proposed Technique

Binary genetic algorithm (BGA) is used to solve the optimization problem of the dissertation.

The optimization of PMU placement is done in following steps by BGA:

Step 1: Initialization

All the required initialization has been made in this phase. Selection of the population size, maximum number of iterations, number of binary bits in each gene, number of genes in each chromosome etc. are determined according to the necessity. Besides, probability percentage for selection, crossover, mutation has been decided. Maximum and minimum limits for the variable values is also defined in this phase.

Step 2: Generation of initial population

A set of initial population has been created in this phase based on the provided value of population size. The fitness function, the NCE value, has been calculated for the initial population. Later, this will be replaced by the better fitted populations in the further loops of BGA unless the global optima is reached.

Step 3: Selection

This phase of BGA does the work of selecting two parents. Fitness of the two randomly selected candidate solutions are calculated. If the 1st candidate is better than 2nd in terms of fitness, it will be selected as the 1st parent. Similarly, second parent will be selected and both parents will be converted into binary form for the further steps.

Step 4: Crossover

Crossover is conducted over the pair of parents generated in Step 3. Single point crossover selects a random point in between the binary strings of the parents. Binary bits interchange their position with respect to the selected point and thus two children are generated. Double point crossover does the same work in terms of two randomly selected points.

After the crossover is done, it is needed to check whether any of the child has violated any of the constraint or not. If violated, that child will remain same as the corresponding parent.

Step 5: Mutation

This phase checks the chromosomes bit by bit and if the mutation probability permits, mutation happens. After mutation, it is again required to check whether the newly generated children have broken any constraint condition or not.

Step 6: Update the solution

The newly generated population in step 5 checks its fitness function. If the fitness is better than the saved one in step 2, then update it. Otherwise, keep the previous solution as it is and goes for the next iteration.

Thus, the solution keeps updating in each of the iterations until the stopping criteria is satisfied. Two stopping criterions are used in this dissertation:

1. If the number of iteration reaches the provided maximum limit.
2. If the value of error indicator does not change for a predefined number of iterations.

The proposed technique of PMU placement is different from the approaches available in the literature as it combines the following features into a single optimization problem:

- Finds the optimal set for any limited number of PMUs
- Finds the solution to ensure maximum estimation accuracy
- Suitable for the power system installed with any estimator
- Covers the critical zone to minimize the harm of bad-data
- Uses an intelligent optimization technique, GA, for solution
- Suitable to apply for planning stage in a SCADA system

The whole procedure of BGA in reaching the global optima is represented below in Figure 4.4:

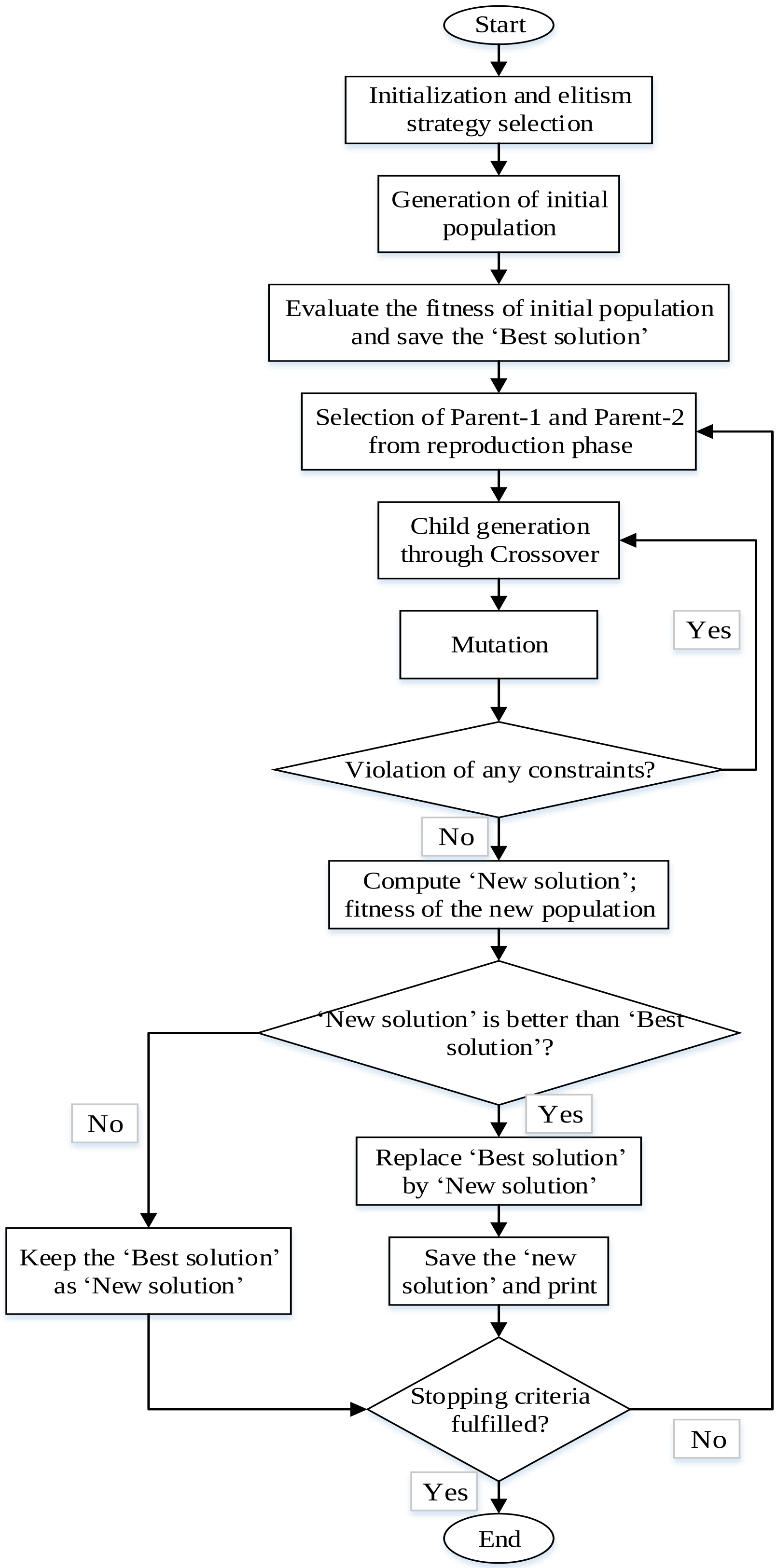

Figure 4.4 Flow diagram of the GA procedure [104]

4.6 Heuristic Approach of PMU Placement

A heuristic approach of PMU placement has been proposed in [17][105] which considers enhancing the estimation accuracy as the principal purpose of deploying PMUs in a power system. It has been implemented with WLS and both voltage and current phasors are considered. The performance of the estimator is assessed by an error indicator called normalized cumulative error (NCE) which is the absolute summation of all the differences between actual values and estimated values of the power system states (voltage-magnitudes (V_m) and phase-angles (V_a)) in normalized form. It is given the name as normalized cumulative error (NCE) indicator.

$$NCE = \frac{1}{2 \times n} \left(\sum_{i=1}^{2n} \left| Actual_i - Estimated_i \right| \right)$$

The proposed PMU placement strategy of this dissertation has the similar objective but solved with genetic algorithm (GA) based optimization technique.

In the heuristic approach, each bus can be equipped with only one PMU. After each installation, state estimation algorithm is executed and the estimation accuracy is evaluated by calculating NCE value.

This algorithm assumes that the system is already observable by traditional measurements and PMUs are to be placed to improve the estimation accuracy. Slack bus – usually bus 1 – in the network is the reference bus where a PMU is installed in the beginning to provide an accurate reference for other buses. This heuristic algorithm places PMUs incrementally bus by bus. Before each placement, it tests all the candidate buses and the bus with lowest indicator value is chosen. The algorithm is explained in reference [105] in detail.

For example, bus-1 is the reference bus for 14-bus system. Therefore bus-1 is an automatic choice for PMU installation. Remaining 13 buses are the candidate buses now. The heuristic approach will search for the 2nd bus location among all the candidate buses which gives the lowest indicator. After that, it will search for the 3rd location with least estimation error and thus the process will carry on till it installs the number of PMUs required by the utility.

This algorithm provides a very efficient placement technique. It solves the placement problem by providing both the number and bus location of PMUs needed to reach a desired estimation accuracy.

However, the heuristic approach of PMU placement has a drawback of falling trapped in local optima sometimes, while searching for an optimal PMU set. The phenomenon will be clearly addressed in the chapter of simulation results.

CHAPTER 5

SIMULATION RESULTS OF ESTIMATION PERFORMANCE

All the results for state estimation are presented in this chapter to prove the effectiveness of the proposed robust estimators: HLMR and ULMR. Before presenting the results, the detail procedure of test case preparation is addressed. The key features of test-case preparation for the estimation work are presented in separate subchapters like measurement simulation, meter distribution, bad-data preparation, performance indicator, standard deviation etc. The estimation performance of HLMR and ULMR is compared with WLS and WLAV for 14-, 30- and 118- bus IEEE power systems. However, post-processed version of WLS is also introduced for comparison purpose. Both the accuracy and computational efficiency are considered in the results preparation.

5.1 Preparation for State Estimation Process

5.1.1 Measurement Simulation

A state estimator works with redundant amount of meter readings. SCADA measurement system collects these measurements from power meters, current transformer, potential transformer and send to the estimator. The meter measurements are mixed with error due to various reasons like low accuracy, noise, aging of the meters, wrong calibration, incomplete metering or communication error. Simulation of these erroneous measurements can be made by following equation:

$$z_i = true_i \left(1 + RND \times \sigma_i\right)$$

Where, i is the measurement count,

z_i is the measurement value from i^{th} meter,

$true_i$ is the actual value of i^{th} measurement found from load flow analysis. Newton Raphson power flow technique is used to find out the true values of the states which will be used further to check the estimation performance.

σ_i is the standard deviation of i^{th} meter reading from the true-value.

RND represents random number with zero mean and normal distribution varying between (-1 to 1).

5.1.2 Standard Deviation (σ) of the Meter and Initial Tolerance (T_{ini}) for Updated LMR

Standard deviation (SD) of a meter reading reflects the accuracy of that meter. The SD for each of the meter types need to be chosen carefully while doing estimation with WLS and WLAV. The voltage magnitude meter readings should have maximum weight during the process of estimation and the reactive values of injection and flow should have least weight. Real power injection and flow should have the weight in between them [14]. As because the weight applied to a meter measurement is the inverse of the corresponding SD value, it is required to give the maximum value of standard deviation to reactive values, then to real values and the minimum values to the voltage magnitude.

For PMU meter readings, all the measurements should have high weight compared to the SCADA meter because of the accuracy of the measurement. Table 5.1 shows all the standard deviation (σ) values considered in this work. The tolerance values for initial estimation of updated LMR (ULMR) has been chosen using the same pattern of standard deviation values. Maximum tolerable limit is given to reactive values of injection and flows while minimum values are given to voltage magnitude meter readings. The values of initial tolerance for ULMR are provided in Table 5.2 below.

Table 5.1 Standard deviation for different meter types [106]

Measurement Type	σ for SCADA meters	σ for PMU meters
Real power flow ($P_{flow[ij]}$, $P_{flow[ji]}$)	0.02	0.0002
Real power injection (P_{inj})	0.02	0.0002
Reactive power flow ($Q_{flow[ij]}$, $Q_{flow[ji]}$)	0.04	0.0004
Reactive power injection (Q_{inj})	0.04	0.0004
Vm_i	0.01	0.0001

Table 5.2 List of initial tolerances for Updated LMR

Measurement Types	Initial tolerance (T_{ini}) for Updated LMR
Voltage Magnitude	0.001
Real Power Injection	0.0015
Reactive Power Injection	0.002
Real Power Flow	0.0015
Reactive Power Flow	0.002

5.1.3 SCADA Meter Distributions

Three IEEE standard power systems with 14-, 30-, and 118-buses are considered for simulation work. Measurement distribution for three test cases are summarized below in Table 5.3:

Table 5.3 Summary of the test cases

	14-**bus**	**30-bus**	**118-bus**
Total Measurements	55	126	440
Redundancy	2.03	2.13	1.87
Number of voltage Magnitudes (Vm)	4	14	62
Number of Real power injections (P_i)	9	16	55
Number of Reactive power injections (Q_i)	8	15	55
Number of Real power flows from a bus (P_{i-j})	11	25	68
Number of Reactive power flows from a bus (Q_{i-j})	11	24	68
Number of Real power flows to a bus (P_{j-i})	6	16	66
Number of Reactive power flows to a bus (Q_{j-i})	6	16	66

Details meter distribution for 14-, 30-, and 118-bus SCADA measurement test cases are presented below in Table 5.4, Table 5.5 and Table 5.6, respectively.

Table 5.4 Meter Distribution of 14-bus test case

Measurement Type	**Measurements Distribution**
$P_{flow[ij]}$	P_1-2, P_1-5, P_2-3, P_3-4, P_4-7, P_6-11, P_6-13, P_7-8, P_9-14, P_12-13, P_13-14
$P_{flow[ji]}$	P_2-1, P_3-2, P_5-4, P_11-6, P_8-7, P_13-12
P_{inj}.	P_1, P_2, P_3, P_6, P_7, P_9, P_10, P_12, P_13
$Q_{flow[ij]}$	Q_1-2, Q_1-5, Q_2-3, Q_3-4, Q_4-7, Q_6-11, Q_6-13, Q_7-8, Q_9-14, Q_12-13, Q_13-14
$Q_{flow[ji]}$	Q_2-1, Q_3-2, Q_5-4, Q_11-6, Q_8-7, Q_13-12
Q_{inj}	Q_1, Q_2, Q_3, Q_6, Q_9, Q_10, Q_12, Q_13
Vm_i	Vm_1, Vm_3, Vm_11, Vm_13

Table 5.5 Meter Distribution of 30-bus test case

Measurement Type	Measurements Distribution
$P_{flow[ij]}$	P_1-3, P_2-4, P_2-5, P_4-6, P_5-7, P_6-7, P_6-8, P_6-9, P_6-10, P_9-11, P_12-13, P_12-14, P_12-16, P_14-15, P_15-18, P_18-19, P_10-17, P_22-24, P_23-24, P_24-25, P_25-26, P_25-27, P_28-27, P_27-30, P_29-30
$P_{flow[ji]}$	P_2-1, P_4-3, P_6-2, P_10-9, P_12-4, P_15-12, P_20-19, P_20-10, P_21-10, P_22-21, P_23-15, P_24-22, P_24-23, P_27-28, P_30-29, P_28-8
P_{inj}	P_1, P_2, P_4, P_5, P_7, P_9, P_10, P_14, P_15, P_16, P_18, P_19, P_21, P_24, P_29, P_30
$Q_{flow[ij]}$	Q_1-3, Q_2-4, Q_2-5, Q_4-6, Q_5-7, Q_6-7, Q_6-8, Q_6-9, Q_9-11, Q_12-13, Q_12-14, Q_12-16, Q_14-15, Q_15-18, Q_18-19, Q_10-17, Q_22-24, Q_23-24, Q_24-25, Q_25-26, Q_25-27, Q_28-27, Q_27-30, Q_29-30
$Q_{flow[ji]}$	Q_2-1, Q_4-3, Q_6-2, Q_10-9, Q_12-4, Q_15-12, Q_20-19, Q_20-10, Q_21-10, Q_22-21, Q_23-15, Q_24-22, Q_24-23, Q_27-28, Q_30-29, Q_28-8
Q_{inj}	Q_1, Q_2, Q_4, Q_5, Q_7, Q_9, Q_10, Q_14, Q15, Q_16, Q_18, Q_19, Q_21, Q_24, Q_30
Vm_i	Vm_1, Vm_3, Vm_4, Vm_5, Vm_8, Vm_10, Vm_12, Vm_18, Vm_21, Vm_24, Vm_25, Vm_26, Vm_28, Vm_29

Table 5.6 Meter Distribution of 118-bus test case

Measurement Type	Measurements Distribution
$P_{flow[ij]}$	P_1-2, P_3-5, P_5-6, P_6-7, P_9-10, P_4-11, P_5-11, P_2-12, P_7-12, P_12-14, P_14-15, P_17-18, P_21-22, P_23-24, P_28-29, P_30-17, P_17-31, P_23-32, P_34-36, P_37-40, P_39-40, P_40-41, P_43-44, P_34-43, P_46-48, P_45-49, P_52-53, P_54-55, P_56-57, P_50-57, P_51-58, P_59-60, P_60-62, P_64-65, P_62-67, P_65-68, P_47-69, P_71-72, P_71-73, P_69-75, P_74-75, P_76-77, P_78-79, P_81-80, P_77-82, P_84-85, P_86-87, P_85-88, P_91-92, P_92-93, P_94-95, P_82-96, P_92-100, P_95-96, P_98-100, P_99-100, P_100-101, P_101-102, P_100-106, P_105-108, P_108-109, P_109-110, P_17-113, P_27-115, P_114-115, P_12-117, P_75-118, P_76-118

$P_{flow[ji]}$	P_11-12, P_11-13, P_13-15, P_15-17, P_18-19, P_20-21, P_21-22, P_22-23, P_23-25, P_26-25, P_27-28, P_8-30, P_29-31, P_19-34, P_35-37, P_33-37, P_30-38, P_40-42, P_41-42, P_46-47, P_42-49, P_42-49, P_48-49, P_49-50, P_49-51, P_51-52, P_49-54, P_54-56, P_55-56, P_56-58, P_54-59, P_56-59, P_59-61, P_60-61, P_63-59, P_63-64, P_49-66, P_62-66, P_65-66, P_66-67, P_49-69, P_68-69, P_24-70, P_24-72, P_70-74, P_69-77, P_75-77, P_79-80, P_82-83, P_85-86, P_86-87, P_88-89, P_89-90, P_92-94, P_94-96, P_80-98, P_94-100, P_96-97, P_100-103, P_104-105, P_105-105, P_106-107, P_108-109, P_32-113, P_32-114, P_68-116
P_{inj}.	P_3, P_4, P_8, P_9, P_12, P_13, P_15, P_16, P_19, P_20, P_24, P_25, P_30, P_31, P_33, P_35, P_36, P_38, P_42, P_44, P_46, P_47, P_49, P_52, P_53, P_54, P_55, P_61, P_63, P_64, P_66, P_68, P_70, P_71, P_77, P_79, P_81, P_83, P_85, P_86, P_90, P_92, P_96, P_97, P_98, P_99, P_102, P_104, P_105, P_110, P_111, P_112, P_116, P_117, P_118
$Q_{flow[ij]}$	Q_1-2, Q_3-5, Q_5-6, Q_6-7, Q_9-10, Q_4-11, Q_5-11, Q_2-12, Q_7-12, Q_12-14, Q_14-15, Q_17-18, Q_21-22, Q_23-24, Q_28-29, Q_30-17, Q_17-31, Q_23-32, Q_34-36, Q_37-40, Q_39-40, Q_40-41, Q_43-44, Q_34-43, Q_46-48, Q_45-49, Q_52-53, Q_54-55, Q_ 56-57, Q_50-57, Q_51-58, Q_59-60, Q_60-62, Q_64-65, Q_62-67, Q_65-68, Q_47-69, Q_71-72, Q_71-73, Q_69-75, Q_74-75, Q_76-77, Q_78-79, Q_81-80, Q_77-82, Q_84-85, Q_86-87, Q_85-88, Q_91-92, Q_92-93, Q_94-95, Q_82-96, Q_92-100, Q_95-96, Q_98-100, Q_99-100, Q_100-101, Q_101-102, Q_100-106, Q_105-108, Q_108-109, Q_109-110, Q_17-113, Q_27-115, Q_114-115, Q_12-117, Q_75-118, Q_76-118
$Q_{flow[ji]}$	Q_ 11-12, Q_11-13, Q_13-15, Q_15-17, Q_18-19, Q_20-21, Q_21-22, Q_22-23, Q_23-25, Q_26-25, Q_27-28, Q_8-30, Q_29-31, Q_19-34, Q_35-37, Q_33-37, Q_30-38, Q_40-42, Q_41-42, Q_46-47, Q_ 42-49, Q_42-49, Q_48-49, Q_49-50, Q_49-51, Q_51-52, Q_49-54, Q_54-56, Q_55-56, Q_56-58, Q_54-59, Q_56-59, Q_59-61, Q_60-61, Q_63-59, Q_63-64, Q_49-66, Q_62-66, Q_65-66, Q_66-67, Q_49-69, Q_68-69, Q_24-70, Q_24-72, Q_70-74, Q_69-77, Q_75-77, Q_79-80, Q_82-83, Q_85-86, Q_86-87, Q_88-89, Q_89-90, Q_92-94, Q_94-96, Q_80-98, Q_94-100, Q_96-97, Q_100-103, Q_104-105, Q_105-105, Q_106-107, Q_108-109, Q_32-113, Q_32-114, Q_68-116,
Q_{inj}	Q_3, Q_4, Q_8, Q_9, Q_12, Q_13, Q_15, Q_16, Q_19, Q_20, Q_24, Q_25, Q_30, Q_31, Q_33, Q_35, Q_36, Q_38, Q_42, Q_44, Q_46, Q_47, Q_49, Q_52, Q_53, Q_54, Q_55, Q_61, Q_63, Q_64, Q_66, Q_68, Q_70, Q_71, Q_77,Q_79, Q_81, Q_83, Q_85, Q_86, Q_89, Q_90, Q_92, Q_96, Q_97, Q_98, Q_99, Q_102, Q_104, Q_105, Q_110, Q_111, Q_112, Q_116, Q_117, Q_118

Vm_i	Vm_2, Vm_3, Vm_4, Vm_5, Vm_9, Vm_12, Vm_15, Vm_17, Vm_18, Vm_21, Vm_23, Vm_24, Vm_25, Vm_27, Vm_28, Vm_29, Vm_30, Vm_34, Vm_36,Vm_37,Vm_40,Vm_42,Vm_44,Vm_45, Vm_46, Vm_49, Vm_51, Vm_53, Vm_54,Vm_56, Vm_57, Vm_59, Vm_62, Vm_63, Vm_64, Vm_68 Vm_69, Vm_70, Vm_71, Vm_73, Vm_75, Vm_76, Vm_77,Vm_80,Vm_82,Vm_85,Vm_86,Vm_91. Vm_92, Vm_94, Vm_100, Vm_101, Vm_102, Vm_103, Vm_105, Vm_107, Vm_110, Vm_111, Vm_112, Vm_113, Vm_114

5.1.4 Bad-data Simulation

Simulation is carried out on 14-, 30- and 118- buses to investigate the performance of the estimators with different bad-data scenarios. When simulating a bad-data for a power-flow meter or a power-injection meter, the value of the bad-data is considered as the opposite polarity of the original value. For the case of voltage-magnitude meters, five times the sigma value is added or subtracted from the meter reading to make it an outlier. Table 5.7 shows three single bad-data (SBD-) scenarios: power-injection, power-flow, and voltage-magnitude along with two multiple bad-data scenarios.

Table 5.7 Different bad-data locations in 14-, 30- and 118- bus systems

Bad-data Types	**Bad-data Locations**		
	14-bus	**30-bus**	**118-bus**
SBD-1	Q_1-5	P_1-3	P_5-6
SBD-2	Q_1	Q_14	Q_13
SBD-3	Vm_3	Vm_10	Vm_51
MNI	Q_6-11, Q_1, Vm_3	Q_14, P_2-1, P_15-18, Vm_1, Vm_24	Q_13, P_50-57, P_4-11, Q_14-15, Vm_3, Vm_24, Vm_30
MI	Q_2-1, Q_3, Vm_1	P_5, P_2-1, P_12-14, Q_12-14, Vm_5	Q_9, P_4-11, P_12-14, Q_12-14, Vm_9, Vm_4, Vm_5,

Three bad-data meters are simulated in the 14-bus system for both multiple non-interacting (MNI) and multiple interacting (MI) cases. A total of five and seven bad-data meters are simulated in the 30- and 118-bus system for both MNI and MI cases, respectively. It has been considered that the measurement which is fed as dad-data to state estimator is neither a critical measurement [103] and nor it has poor local redundancy [92].

5.1.5 Performance Indicator

Different estimators deal with different objective functions. WLS tries to minimize the square of the residual, LAV tries to get the minimum absolute value of error and LMR aims to reduce the number of rejected measurements to get the best estimates. So, to make a fair comparison between different estimators, it is necessary to use an appropriate indicator which is applicable for all and reflects the performance of the estimator.

The performance of the estimators is evaluated based on the normalized cumulative error (NCE) indicator which is the absolute summation of all the differences between actual values (A_i) and estimated values (E_i) of the power system states. A_{m_i} and A_{θ_i} are the actual values of the voltage-magnitudes and phase-angles, respectively. Similarly, E_{m_i} and E_{θ_i} are representing the estimated values of the voltage-magnitudes and phase-angles [17], [80].

$$NCE = \frac{1}{2*n}\left(\sum_{i=1}^{2n}\left|A_i - E_i\right|\right)$$

$$NCE = \frac{1}{2*n}\left(\sum_{i=1}^{n}\left[\left|A_{m_i} - E_{m_i}\right| + \left|A_{\theta_i} - E_{\theta_i}\right|\right]\right)$$

n is the number of buses present in the power system. The normalized error indicator will ensure the fair comparison between power systems of different sizes. Lower NCE indicator reflects the better performance of an estimator and vice versa.

Besides of NCE indicator, graphical representation of the estimated state variables, details estimated results of the bad-data locations and the computational efficiency of the estimators are also presented in this work to prove the effectiveness of the proposed estimators.

Simulation is carried out in MATLAB simulation software. To solve the linear programming problem formulation of WLAV, “lpsolve” function of the MATLAB has been used while “intlinprog” function is used to deal with the mixed integer programming formulation of LMR. All test cases are performed on a laptop with Intel (R) core (TM) i5, 2.30 GHz CPU and 8 GB RAM. The value of M for LMR estimator is taken as 500 which is large enough to ensure zero effect of the rejected values on estimation process and at the same time, not that large to create any computational burden.

Largest normalized residual (LNR) based technique has been adopted for bad-data identification and elimination for post-processing of WLS.

5.2 State Estimation Results for 14-bus System

5.2.1 NCE Indicator

IEEE 14-, 30-, and 118-bus systems has been used to investigate the performance of the proposed estimators: Hybrid LMR (HLMR) and Updated LMR (ULMR). WLS and WLAV has been used for the comparison purpose. A test case with white noise measurements only, three single bad-data scenarios and two multiple bad-data scenarios has been presented in simulation results. All the NCE indicator results for 14-bus system are summarized in Table 5.8 below.

Table 5.8 NCE indicator results for 14-bus system

	WLS	WLAV	LMR	H LMR	U LMR
White noises	1.93E-02	4.92E-02	0.061815	0.748E-02	1.22E-02
SBD-1	2.84E-02	4.92E-02	0.19014	0.715E-02	1.257E-02
SBD-2	4.73E-02	4.91E-02	0.1561	0.758E-02	1.23E-02
SBD-3	3.89E-02	10.1E-02	0.10552	0.748E-02	1.22E-02
MNI	9.97E-02	4.94E-02	0.14498	0.666E-02	1.17E-02
MI	13.1E-02	5.53E-02	0.049179	0.604E-02	1.31E-02

It is seen from the table that the ULMR and HLMR shows better performance in all the cases than WLS and WLAV. When the measurements are only mixed with white noises, WLS showed satisfactory performance with NCE indicator of 1.93E-02. But the presence of bad-data hampers the performance badly, especially in MI and MNI cases. WLAV, being a robust estimator, showed superior performance than WLS in multiple bad-data cases. But it fails in SBD-3 case and results very high indicator of 10.1E-02. WLS outperforms WLAV in white-noise-only and SBD-1 by large margin.

The proposed two estimators, HLMR and ULMR result almost the same error indicator in all the 6 cases. Hybrid LMR outperforms WLS, WLAV and ULMR in every case. The NCE indicator for HLMR remains almost constant around 0.75E-02 for white noise and three SBD cases. For multiple bad-data occurrence, error indicator reduces to even lower values and showed the robustness of the estimator. ULMR is found very robust in all the bad-data cases and the error indicators are way lower than WLS and WLAV. Only the case of single bad-data in power flow hampers the performance of ULMR slightly.

5.2.2 Estimation Performance at Bad-data Locations

It can be observed from the results that the WLS estimator is very sensitive to the presence of bad-data and need further steps to filter out the bad-data. It is important to analyze the estimated values of the locations where the bad-data are applied. Table 5.9 shows the details of bad-data occurrence cases for the 14-bus system. Bad-data locations, actual values, applied bad measurement values and the corresponding estimated values for each estimator are presented in the tables which reflects clearly how the estimators behave in the bad-data locations.

Table 5.9 Bad-data estimation results for 14-bus system

Bad-data types	Bad-data Location	Actual	Meas.	Estimated			
				WLS	WLAV	H-LMR	U-LMR
SBD-1	Q1-5	0.03854	-0.03805	0.02654	0.03637	0.03748	0.03835
SBD-2	Q1	-0.1655	0.1654	-0.0047	-0.1647	-0.1654	-0.1652
SBD-3	V11	1.0569	1.1102	1.0865	1.1102	1.0602	1.0591
MNI	V13	1.0504	1.1050	1.0765	1.0550	1.0534	1.0538
	Q3	0.0608	-0.0600	-0.0255	0.0559	0.0619	0.0588
	Q1-2	-0.2040	0.2056	-0.1138	-0.2028	-0.2043	-0.2029
MI	V1	1.0600	1.0091	1.0507	1.0585	1.0616	1.0618
	Q3	0.0608	-0.0600	-0.0135	0.0635	0.0616	0.0585
	Q2-1	0.2768	-0.2823	0.1571	0.2788	0.2762	0.2775

It is seen from the table that the WLS estimator fails to estimate the measured values in several cases. For bad-data in Q3 for MNI case and Q2-1 for MI case, the estimated values maintain the opposite polarity compared to the true states. On the other hand, WLAV, HLMR and ULMR show robustness in each of the bad-data location.

5.2.3 Required Time

Computational efficiency is one of the biggest concerns of state estimation process. Table 5.10 shows the required times in second to complete the estimation work for different estimators.

Table 5.10 CPU time (second) comparison between the estimators for 14-bus system

WLS	WLAV	H LMR	U LMR
0.2390	0.2621	0.283613	0.2771

Time taken for WLS is marginally better than other three approaches. Two proposed estimators resulted fair performance by taking around 0.28 second while the WLS takes 0.239 seconds. 14-bus system is still too small in size as a test case to decide whether the proposed approaches are robust or not, in terms of computational efficiency.

5.3 State Estimation Results for 30-bus System

5.3.1 NCE Indicator

Results for 30-bus test cases are presented in Table 5.11. When the test case is not having any bad-data, ULMR performed best among all with the lowest NCE indicator of 1.38E-02. The NCE values for WLS and HLMR are close to each other and both outperforms WLAV.

Table 5.11 NCE indicator results for 30-bus system

	WLS	WLAV	LMR	H LMR	U LMR
White noises	2.01E-02	4.79E-02	0.040966	2.21E-02	1.38E-02
SBD-1	105E-02	4.79E-02	0.069168	2.13E-02	1.85E-02
SBD-2	2.05E-02	5.28E-02	0.067577	2.34E-02	1.43E-02
SBD-3	10.5E-02	4.79E-02	0.047572	2.21E-02	1.38E-02
MNI	168E-02	6.85E-02	0.12651	2.49E-02	1.93E-02
MI	249E-02	4.79E-02	0.075794	2.06E-02	2.96E-02

When the bad-data is applied, WLS fails as an estimator and resulted high error indicator. Especially the NCE values for SBD-1, MI and MNI are very high compared to the other estimators as well as to the white noise case of WLS. Presence of five bad-data together causes the highest impact on it. WLAV showed the robustness under all sorts of bad-data occurrence and the NCE values doesn't deteriorate much. But the performance of WLAV under white-noise-only measurements is the worst among all with the NCE indicator of 4.79E-02.

WLAV outperforms WLS in every bad-data case but can't perform better than LMR in any of the cases. The proposed hybrid estimator shows consistent performance in different bad-data scenarios and the error indicator for it doesn't change for it. The Updated LMR outperforms HLMR in white noise, single bad-data cases and MNI case. But it multiple-interacting bad-data occurrence causes a rise in error indicator for ULMR and made HLMR best among all. Still the NCE value for ULMR for MI case is reasonable and way better than WLS and WLAV.

5.3.2 Graphical Representation of the State Variables

State estimator estimates the state variables of the power system: voltage magnitude of the bus and the phase angle. Better estimation process of the states ensures the accurate estimation of all other power system variables: power injection, power flow etc. Figure 5.1 and Figure 5.2 graphically compared the estimated values with trues values for voltage magnitudes and angles for 30-bus system, respectively, with HLMR estimator. Among six different scenarios, MNI bad-data case has been chosen for the purpose; where 5 bad-data are applied in non-interacting locations. Figure 5.3 and Figure 5.4 present the results for ULMR estimator.

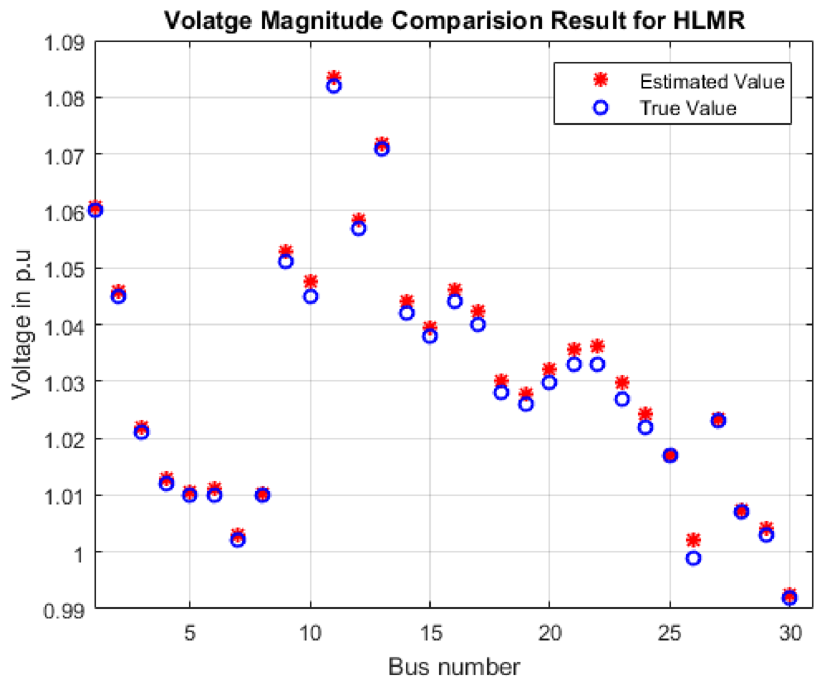

Figure 5.1 Comparison of estimated and actual values of Va by HLMR for 30-bus MNI case

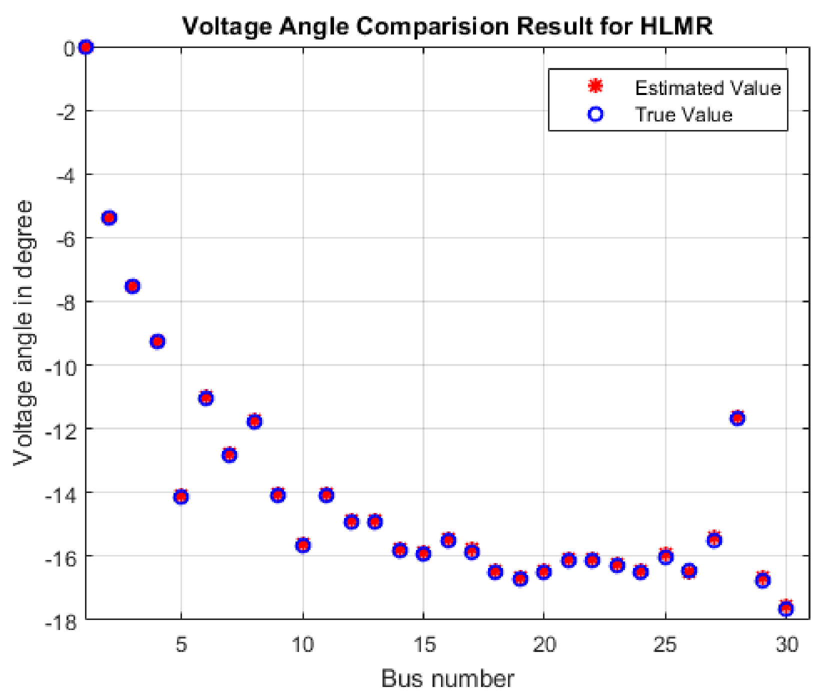

Figure 5.2 Comparison of estimated and actual values of Va by HLMR for 30-bus MNI case

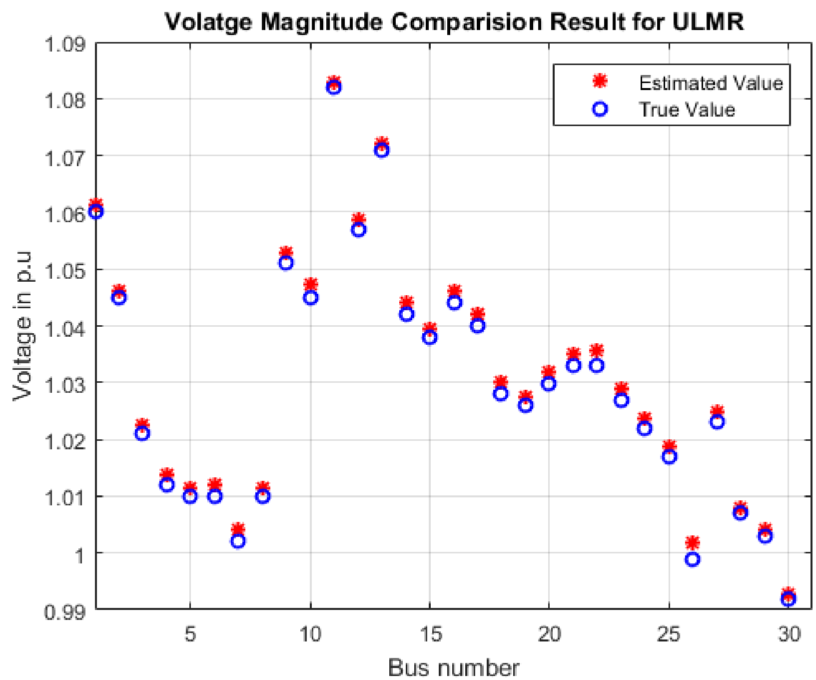

Figure 5.3 Comparison of estimated and actual values of Vm by ULMR for 30-bus MNI case

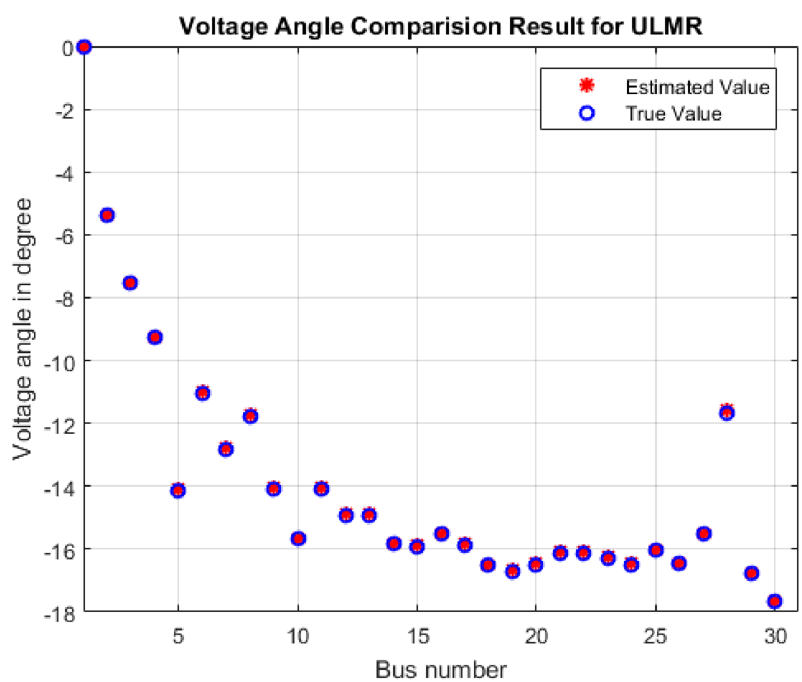

Figure 5.4 Comparison of estimated and actual values of Va by ULMR for 30-bus MNI case

Graphical representation has clearly reflected how the estimated values (denoted by star) follow the actual values (denoted by circle) of the state variables (V_m and V_a), for both the proposed estimators, irrespective of the presence of 5 bad-data in the system. Such an accurate estimation clearly proves the robust nature of the proposed estimators.

5.3.3 Estimation Performance at Bad-data Locations

Three single bad-data cases and two multiple bad-data scenarios with five bad-data together for each are simulated in 30-bus system to test the robustness of the proposed estimators. Table 5.12 shows the detail analysis on the estimated and actual values in the bad-data locations.

Table 5.12 Bad-data estimation results for 30-bus system

Bad-data types	Bad-data Location	Actual	Meas.	Estimated			
				WLS	WLAV	H-LMR	U-LMR
SB-1	P_1-3	0.8765	-0.8707	0.5497	0.8734	0.8752	0.8760
SB-2	Q_14	-0.0160	0.0163	0.0046	0.0006	-0.0120	-0.0140
SB-3	Vm_10	1.0454	1.1491	1.0650	1.0479	1.0468	1.0469
MNI	Vm_1	1.0600	1.1047	1.0495	1.0625	1.0607	1.0613
	Vm_24	1.0218	1.1252	1.0466	1.0266	1.0242	1.0236
	Q_14	-0.0160	0.0163	0.0013	-0.0038	-0.0134	-0.0140
	P 15-18	0.0602	-0.0593	0.0206	0.0591	0.0594	0.0599
	P 2-1	-1.6809	1.6536	-0.7809	-1.6730	-1.6752	-1.6835
MI	Vm_5	1.0100	1.0676	1.0446	1.0112	1.0106	1.0126
	P_5	-0.9420	0.9366	0.2769	-0.9382	-0.9359	-0.9380
	P 1-3	0.8765	-0.8707	0.3628	0.8734	0.8758	0.8773
	P 2-1	-1.6809	1.6536	-0.5287	-1.6710	-1.6740	-1.6816
	Q 2-5	0.0278	-0.0268	-0.0266	0.0274	0.0273	0.0268

It is obvious that the WLS will fail to estimate some of the bad-data properly due to not having any post-processing step with it. But, it is seen from the table that the robust estimator, WLAV also failed in some of the bad-data locations. In SB2 case, WLAV resulted 0.000627 as the estimated value when the actual value is -0.016. Similarly, it fails to estimate the reactive power injection bad-data applied as a part of MNI case.

This is very important to notice that the proposed estimators showed robustness in all the cases. Both ULMR and HLMR estimated the values of bad-data locations whether the bad-data case is single or multiple.

5.3.4 Required Time

In terms of computational efficiency, WLAV is found best among all in 30-bus system. Proposed estimators require larger time than WLAV, but the difference is not that large. WLS requires largest amount of time among all and proves itself the least efficient estimator in terms of computational efficiency. Table 5.13 contains all the required times in second for 30-bus system.

Table 5.13 CPU time (second) comparison between the estimators for 30-bus system

WLS	WLAV	H LMR	U LMR
0.521917	0.3073	0.429863	0.4791

5.4 State Estimation Results for 118-bus System

5.4.1 NCE Indicator

118-bus system is the biggest power system considered for simulation in this work. This is a large test case made of 440 SCADA measurements. So, the simulation results presented below will give a clear picture about the performance of the proposed estimators. Table 5.14 compares between the estimators in terms of NCE indicator.

Table 5.14 NCE indicator results for 118-bus system

	WLS	WLAV	LMR	H LMR	U LMR
White noise	2.30E-02	2.90E-02	0.036053	2.16E-02	2.12E-02
SBD-1	10.2E-02	2.90E-02	0.036614	2.16E-02	2.12E-02
SBD-2	2.35E-02	3.05E-02	0.07109	2.16E-02	1.93E-02
SBD-3	3.19E-02	2.90E-02	0.051658	2.16E-02	2.12E-02
MNI	12.4E-02	2.76E-02	0.040341	2.25E-02	2.11E-02
MI	7.21E-02	3.39E-02	0.055073	2.24E-02	2.23E-02

When there is no bad-data present in the system, updated LMR performs best among all with lowest indicator of 2.12E-02. Hybrid LMR has almost the same NCE value. Both proposed estimators outperform WLS and WLAV in this case. WLS shows better performance than WLAV with a very good NCE value of 2.30E-02.

When the bad-data is applied in the system, NCE values of WLS test cases increase to a significant high value for SBD-1, MNI and MI case. As a robust estimator, WLAV shows robustness in every bad-data occurrence. Except MI case, the NCE indicator remain constant around 2.90E-02.

The performance of HLMR and ULMR has set a perfect example of robustness. The NCE indicator remains almost constant in every case whether the bad-data is applied in single number or multiple. NCE value for any case for any of them is better than the corresponding value of WLS and WLAV. In terms of NCE value, ULMR is found better than HLMR even though the values are very close to each other. NCE value of ULMR in SBD-3 case (1.93E-02) is seen lower than the normal white noise case (2.12E-02) which is a proof of the proper tuning of the tolerance values. For some bad-data cases, the tolerance value selection could make the estimator even better than the normal white noise case.

5.4.2 Estimation Performance at Bad-data Locations

Three single bad-data cases and two multiple bad-data cases with total of seven bad measurements are tested on 118-bus test case to check the robustness. The Table 5.15

shows the actual, measurement and estimated values of the bad-data locations. It clearly picturizes the way estimators respond to the applied bad-data.

Table 5.15 Bad-data estimation results for 118-bus system

Bad-data types	**Bad-data Location**	**Actual**	**Meas.**	**Estimated**			
				WLS	**WLAV**	**H-LMR**	**U-LMR**
SB-1	P 5-6	0.8847	-0.8771	-0.1646	0.8858	0.8827	0.8826
SB-2	Q_13	-0.1600	0.1639	0.0327	-0.1236	-0.1646	-0.1563
SB-3	Vm_51	0.9669	1.0262	0.9756	0.9642	0.9675	0.9678
MNI	Vm_3	0.9677	1.0494	0.9804	0.9654	0.9670	0.9698
	Vm_24	0.9920	1.0673	1.0067	0.9963	0.9939	0.9930
	Vm_30	0.9853	1.0691	0.9941	0.9872	0.9859	0.9868
	Q_13	-0.1600	0.1639	0.0280	-0.1074	-0.1636	-0.1563
	P 4-11	0.6423	-0.6419	0.3058	0.6364	0.6377	0.6381
	P 50-57	0.3588	-0.3629	-0.0466	0.3732	0.3702	0.3690
	Q 14-15	0.0314	-0.0323	0.0064	0.0008	0.0286	0.0331
MI	Vm_4	0.9980	1.0388	1.0021	1.0022	0.9978	1.0004
	Vm_5	1.0020	1.0445	1.0059	1.0062	1.0018	1.0044
	Vm_9	1.0429	1.0963	1.0509	1.0491	1.0437	1.0452
	Q_13	-0.1600	0.1639	0.0288	-0.1637	-0.1646	-0.1563
	P 4-11	0.6423	-0.6419	0.3058	0.6366	0.6380	0.6376
	P 12-14	0.1831	-0.1837	-0.1032	0.1818	0.1772	0.1808
	Q 12-14	0.0262	-0.0261	-0.0014	-0.0261	0.0265	0.0424

It is found that the estimated value of WLS is having the opposite polarity for SBD-1 and SBD-2 which reflects the complete failure of estimation. WLAV is much better than WLS in estimating the bad-data but still fails to ensure the accuracy for several occasions. The highlighted locations of table show that the estimated values are far away from the actual values. It is important to notice that the WLAV fails to estimate the bad-data location Q_12-14 and results the opposite polarity in estimated value compared to the true value.

Both the hybrid and updated version of LMR are seen very accurate in estimating the states correctly in the bad-data locations. In MI case, a pair of bad-data is applied as real and reactive power flows (P_12-14 and Q_12-14) to make the case highly severe. This is the location where the WLAV fails even being a robust estimator. But it is very significant to notice that the proposed two estimators can deal with such severe cases and the estimated values are reasonably close to the true values. Except these two locations, the estimation accuracy for ULMR and HLMR are seen very high for remaining bad-data occurrence locations.

5.4.3 Required Time

WLS is found taking a long time to complete the simulation work while applying in 118-bus system. WLAV takes a reasonable amount of time of 1.4 second where both the proposed estimators perform very good in terms of computational efficiency. Less than 1.2 seconds time is required for both and thus it proves the estimator efficient in dealing with computational burden. The results are presented in Table 5.16 below.

Table 5.16 CPU time (second) comparison between the estimators for 118-bus system

WLS	WLAV	H LMR	U LMR
1.6748	1.4162	1.162523	1.1292

5.5 Comparison of Proposed Estimators with Post-processed WLS (WLS-PP)

None of the estimation approaches presented in the previous chapters has any separate post-processing feature. LMR and WLAV, being the robust estimator, detect and clean the outliers within the estimation process. WLS, because of not having any bad-data cleaning module within itself, fails badly in the bad-data cases, as seen in the chapters 6.2-6.5.

This section presents the performance of WLS if a separate module of bad-data removal is added. The post-processed WLS will be compared with the proposed estimators to check the ultimate robustness. By checking the normalized residuals of the measurements, bad-data presence is detected, eliminated and then used for estimation in the further step [107] [108].

5.5.1 Performance Comparison with Hybrid LMR

The performance indicators for hybrid LMR is compared with post-processed WLS in the Table 5.17 below for all three test cases. The bad-data locations are kept same as before.

Table 5.17 Comparison of Hybrid LMR with post-processed WLS

	14-bus		30-bus		118-bus	
	WLS-PP	HLMR	WLS-PP	HLMR	WLS-PP	HLMR
White noise	1.93E-02	0.748E-02	2.01E-02	2.21E-02	2.30E-02	2.16E-02
SBD-1	1.96E-02	0.736E-02	1.76E-02	2.13E-02	2.25E-02	2.16E-02
SBD-2	2.09E-02	0.758E-02	2.00E-02	2.34E-02	2.30E-02	2.16E-02
SBD-3	1.94E-02	0.748E-02	1.88E-02	2.21E-02	2.21E-02	2.16E-02
MNI	1.13E-02	0.666E-02	2.27E-02	2.49E-02	2.41E-02	2.25E-02
MI	2.19E-02	0.604E-02	2.13E-02	2.06E-02	2.39E-02	2.24E-02

It has been seen from the table that the result of WLS has been improved significantly because of using the separate process to clean the bad-data. Still the robust hybrid estimator performs very well if compared to it. In all the cases of 14- and 118-bus system, the proposed estimator outperforms the WLS-PP. In 30-bus system, post-processed WLS performs better but the difference with HLMR is very small.

5.5.2 Performance Comparison with Updated LMR

The other proposed robust estimator, updated LMR, is then compared with post-processed WLS and the results are presented in the Table 5.18 below.

Table 5.18 Comparison of Updated LMR with post-processed WLS

	14-bus		30-bus		118-bus	
	WLS-PP	ULMR	WLS-PP	ULMR	WLS-PP	ULMR
White noise	1.93E-02	1.22E-02	2.01E-02	1.38E-02	2.30E-02	2.12E-02
SBD-1	1.93E-02	2.03E-02	1.76E-02	1.85E-02	2.25E-02	2.12E-02
SBD-2	2.09E-02	1.23E-02	2.00E-02	1.43E-02	2.30E-02	1.93E-02
SBD-3	1.94E-02	1.22E-02	1.88E-02	1.38E-02	2.21E-02	2.12E-02
MNI	1.13E-02	1.17E-02	2.27E-02	1.93E-02	2.41E-02	2.11E-02
MI	2.19E-02	1.31E-02	2.13E-02	2.96E-02	2.39E-02	2.23E-02

It is clearly visible from the table that the updated LMR outperforms the WLS-PP in almost every case. Because of removing the bad measurements in separate module, the performance of WLS doesn't deteriorate now like normal WLS and the results are much improved than WLS without post-processing feature. Error indicator remains almost constant around 2.30E-02 for the 118-bus system. But still the proposed approach of robust estimator shows better performance in each bad-data case and results lower error indicator.

5.5.3 Computational Efficiency Comparison

WLS with post-processing step has the biggest drawback of requiring long time for estimation as it needs to check and clean the present bad-data manually before doing the estimation. Moreover, in the case of multiple bad-data presence, WLS-PP requires a sequential approach to clean those one after another and thus results a very poor computational efficiency [108], [109]. The time requirement of the proposed estimators is compared with WLS-PP in

Table 5.19 below:

Table 5.19 CPU time (second) comparison with WLS-PP

No. of bad-data	**30-bus system**			**118-bus system**		
	WLS-PP	**H LMR**	**U LMR**	**WLS-PP**	**H LMR**	**U LMR**
0	0.519	0.4299	0.4791	1.6748	1.1625	1.1292

1	0.750	0.4299	0.4791	1.844	1.1625	1.1292
2	0.892	0.4299	0.4791	1.980	1.1625	1.1292
5	1.114	0.4299	0.4791	2.205	1.1625	1.1292

It is clearly seen from the table that the proposed estimators are far better than WLS-PP in terms of computational efficiency, which is a vital factor in state estimation process. For a single bad-data presence, it has been found that the WLS with post-processing scheme requires around 4 seconds where both the proposed estimators need less than 1.5 seconds in 118-bus system. With the increase of bad-data presence, required time for PP-WLS increases more. Time required for 5 bad-data cases are significantly high for both the test cases.

Though it's not fair to compare a single module estimator like HLMR with a double module approach like WLS-PP, it is still chosen for comparison as most of the current-day power systems are installed with WLS-based estimators. Therefore, the proposed HLMR could be a better replacement of WLS-PP in the state estimator market.

5.6 Robustness of the proposed estimators under meter loss

The effect of bad-data is already examined on the proposed estimators. It has been found that the estimators can successfully deal with the bad measurements, even though they are multiple in number. Another way of checking the robustness of an estimator is to check the performance under meter loss. The measuring devices, located in various parts of the power system, not only prone to send wrong measurements but also got damaged sometimes. Due to harsh weather or some other reasons, a meter can fail to send the measurement to the remote terminal unit (RTU). This will lead the loss of that measurement from the measurement series used by the estimator.

To check the robustness of the proposed estimators, HLMR and ULMR, under meter loss scenario, 30-bus test case has been used in this section. The 30-bus test case initially had 126 measurements with 2.16 redundancy. To check the robustness, some of the measurements has been removed from the system (2 at a time) and the NCE error has been calculated for both the proposed estimators. All the results are presented below in Table 5.20.

Table 5.20 NCE indicators of HLMR and ULMR under meter loss

No. of Measurements	NCE indicator for HLMR	NCE Indicator for ULMR
126	2.21E-02	1.38E-02
124	2.13E-02	1.49E-02
122	2.20E-02	1.87E-02
120	2.39E-02	1.42E-02
118	2.37E-02	1.84E-02

Initially, with the total of 126 measurements, HLMR had the NCE value of 0.0221 and ULMR had 0.0138. After removing 2 measurements from the system, NCE indicators remain almost same for both the estimators. For ULMR, it is increased to a larger value, but the change is very small. For HLMR, better NCE result is achieved even though the measurements are removed. It happened for the rejection characteristics of LMR estimator. Similarly, the removal of measurements is continued until the total number of measurements reaches 118 from 126. For each of the case, corresponding NCE indicators ensure that the proposed estimators are very robust under the meter loss scenario. Removal of the measurement causes the deterioration of the estimation performance for some cases, but in a reasonable range.

5.7 Summary of the Estimation Results

Chapter-5 presents the estimation performance for two proposed estimators: HLMR and ULMR. The results are generated under different scenarios:

- With white noise mixed measurements
- With single bad-data presence as voltage-magnitude, power-flow and power injection
- With multiple interacting and multiple non-interacting bad-data
- With SCADA measurements-based test case
- PMU-mixed measurements with SCADA system
- With varied sizes of test cases

The performance of the proposed estimators is tested in terms of accuracy and computational efficiency.

The comparison is made with WLS and WLAV.

Chapter 5.2 and 5.4 showed that the proposed estimators, HLMR and ULMR, are way better than WLS and WLAV when the measurements are from SCADA system.

Chapter 5.3 ensures that the HLMR is a better option than WLS even if a separate bad-data processing scheme is added with WLS.

Chapter 5.5 compares ULMR with post-processed WLS (WLS-PP) which has a separate feature of eliminating the bad measurements from the test case.

The results clearly proved the effectiveness of the proposed estimators who don't have any separate bad-data processing module but still perform superior to WLS-PP, in terms of computational efficiency in particular.

CHAPTER 6

SIMULATION RESULTS OF OPIMAL PMU PLACEMENT

This chapter presents the simulation results after incorporation of PMU measurements into the existing SCADA system. At the beginning, it has been shown that the inclusion of phasor measurements in any location improves the performance of all the estimators. Later, simulation results for proposed optimal PMU placement are presented. The proposed approach of PMU placement has been compared with a heuristic approach of same objective function. Significance of covering the critical locations by PMU meters is investigated in this chapter. Initialization for the genetic algorithm along with the adopted elitism strategy is addressed in separate subchapters.

6.1 Impact of PMU Placement on Estimation Performance

Chapter 5 presented the estimation results when the measurements are from conventional SCADA system. However, the impact of PMU inclusion on the estimation performance is investigated in this section. Thus, the estimators will work under a mixed measurement (SCADA+PMU) environment. Bus 1 and 2 has been chosen for 30-bus system to place PMUs where bus-1 is the slack bus. 118-bus test-case has been modified by installing the PMUs in bus 68 and 69 where bus-68 is the slack bus. The installed PMU meters will provide some extra phasor measurements of voltages and currents to the SCADA system and will increase the overall redundancy. Details of the added phasor measurements are tabulated in Table 6.1 below.

Table 6.1 Added phasor measurements in SCADA system

Test Cases	PMU installed buses	Measurements from PMU	
		Voltage Phasors	**Current Phasors**
30-bus	1, 2	Vm_1, Vm_2, Va_1, Va_2	I_1-2, I_1-2, I_2-4, I_2-5, I_2-6
118-bus	68, 69	Vm_68, Vm_69, Va_68, Va_69	I_68-69, I_69-70, I_69-75, I_69-77, I_68-116

The results for 30- and 118-bus systems with PMU meter incorporation has been presented below in Table 6.2 and Table 6.3, respectively, with respect to NCE indicator. Case with white noise only, three single bad-data scenarios and two multiple bad-data cases are presented as before. Location of the bad-data are kept same as Table 5.7.

Table 6.2 NCE indicator results for 30-bus system with two PMUs in 1 and 2

	No of Bad-data	WLS	WLAV	H LMR	U LMR
White noise	0	0.828E-02	1.94E-02	0.817E-02	0.647E-02
SBD-1	1	0.918E-02	1.94E-02	1.65E-02	0.980E-02
SBD-2	1	0.968E-02	2.01E-02	1.44E-02	0.683E-02
SBD-3	1	1.30E-02	1.94E-02	0.817E-02	0.647E-02
MNI	5	18.6E-02	9.71E-02	0.990E-02	0.792E-02
MI	5	6.63E-02	1.94E-02	1.06E-02	1.09E-02

Table 6.3 NCE indicator results for 118-bus system with two PMUs in bus 68 & 69

	No of Bad-data	WLS	WLAV	H LMR	U LMR
White noise	0	1.74E-02	3.18E-02	1.77E-02	1.84E-02
SBD-1	1	9.78E-02	3.18E-02	1.77E-02	1.93E-02
SBD-2	1	1.76E-02	3.26E-02	1.78E-02	1.86E-02
SBD-3	1	2.02E-02	3.18E-02	1.73E-02	1.87E-02
MNI	7	11.0E-02	3.16E-02	1.88E-02	1.90E-02
MI	7	6.54E-02	3.78E-02	1.69E-02	2.00E-02

The performance of all the estimators has been improved than before (Table 5.11 and Table 5.14) with the inclusion of new phasor measurements. As the PMU meter readings are very accurate, it always brings a positive change in the efficiency of the estimation. Still the proposed two estimators outperform the other approaches by large margin. Especially for the bad-data cases, the difference is clearly visible between the estimators.

It gives a clear conclusion that the performance of an estimator improves with the addition of new PMU meters. This occurs for two reasons: for addition of high accuracy measurements and for increment of the redundancy. Addition of PMU in any bus location will cause the similar positive impact on the estimation performance.

However, the inclusion of the PMU meters in a SCADA system should be in the optimal locations so that it ensures the maximum service. The optimal PMU locations of the proposed technique are presented in the following chapters.

6.2 Preparation for the Optimization

If any SCADA system installed power system plans to install a restricted number of PMUs to improve the state estimation performance, the proposed method [104] of PMU deployment would be an ideal option to follow. The proposed technique of PMU placement also takes care of the issue of critical measurements. The presence of critical measurements hampers the estimation performance badly if the bad-data comes from critical location or around that. Covering the critical zones during PMU placement will ensure the robustness of the estimation performance of the power system.

6.2.1 Initialization of Genetic Algorithm

The performance of genetic algorithm highly depends upon the proper selection of population size, maximum iteration number, stopping criteria, probability values of selection, mutation and crossover operation. Besides, high crossover probability and low mutation probability will help the searching process to avoid getting trapped in local minima [101], [110]. Detail of the initialization has been presented below in Table 6.4 for GA:

Table 6.4 Details of GA parameters

Criteria	Considered Parameter
Population size	200
Selection Probability	1
Crossover Probability	0.9
Mutation Probability	0.15
Maximum Number of iterations	200
Fitness function	The value of NCE indicator. $NCE = \frac{1}{2*n}(\sum_{i=1}^{2n} \lvert A_i - E_i \rvert)$
Crossover point	30-bus: Double
	118-bus: Triple
Elite Chromosome (PMU must be installed)	Slack bus: Bus-1 for 30-bus and bus-69 for 118-bus system
	Buses which cover the critical zones
Stopping Criteria	1. Reaching the maximum number of iterations
	2. If the fitness value doesn't change for consecutive 100 iterations

The value of population size and the iteration number has been chosen high to ensure the global solution. Slack bus has been chosen as an elite chromosome in GA optimization so that the reference angle of the measurements is accurate and remains the same. The value of the fitness function is the value of *NCE* error indicator. Minimization of the fitness value ensures the better estimation performance. Besides, using such a generalized error indicator will help the proposed optimization technique to be used with any estimator. However, optimal PMU locations for one estimator will be different from another estimator as the objective function directly depends upon the estimation performance.

Crossover point has been chosen based on the size of the chromosome. Because of the larger chromosome length, three points has been chosen for crossover in 118-bus when double point crossover is used in 30-bus system. Stopping criteria has been chosen carefully to ensure that the iteration will not stop unless the global solution is achieved.

The PMUs are incorporated in the state estimation algorithm with the following assumptions [111]:

- The phasor measurements and the traditional measurements are taken at the same snapshot – there is no time skew between them.
- A PMU should be always available at the slack bus so that the reference angle of both measurements is the same.
- When a PMU is installed at a certain bus, it can read the bus voltage phasor in addition to all the branch current phasors connected to that bus and flowing away from that bus.

6.2.2 Elitism Strategy of Optimization

Elitism is the strategy of forcing the GA to keep a certain population as the solution in each generation. It was first proposed by Kenneth De Jong in 1975 [112]. This is a very effective approach of getting an expected solution. For example, for optimization of PMU placement problem, if it is desired to keep a specific bus in the solution set, the concept of 'elitism' will play a key role.

Slack bus has been chosen as an elite chromosome in GA optimization so that the reference angle of the measurements is accurate and remains same. Besides, the buses who cover the critical measurements have been chosen as the elite buses. This will ensure the robustness of the estimation as the bad-data in and around the critical location hampers the estimation performance badly. Table 6.5 shows the detail elitism strategy maintained in the optimization process.

Table 6.5 Elitism strategy of GA

Test cases	Slack bus number	Critical measurements	Critical buses	Elite genes
14-bus	1	N/A	N/A	1
30-bus	1	P_12-13 and Q_12-13	12, 13	1, 12
118-bus	69	P_49-50 and Q_49-50	39, 40	69, 40

After loading the available SCADA measurements of a test case, normalized residuals have been calculated for each measurement. The critical measurements have been identified by calculating normalized residuals as described in section 2.3. 14-bus test case considered in this dissertation has no critical measurement when 30- and 118- bus has got two in each.

Placing PMU in bus-12 covers both the critical measurements (P_12-13 and Q_12-13) for 30-bus. Thus, bus 1 and 12 has been chosen for elitism for 30-bus system as bus-1 is the slack bus.

6.2.3 Type of the PMU Meter

SCADA measurement-based power system is considered in PMU placement optimization. When a PMU is installed at a certain bus, it can provide the corresponding bus-voltage magnitude and phase-angle as well as the branch current phasors flowing 'from' that bus. This increases the redundancy level. If a bus is equipped with both the SCADA and PMU meter, the estimator will likely to consider the PMU reading due to its low standard deviation (high weight). It is also assumed that the phasor measurements and the traditional measurements are taken at the same snapshot – there is no time skew between them.

The additional PMU measurements for a specific set of PMUs are also shown in the Table 6.6 below.

Table 6.6 Additional PMU meters for optimal PMU set 1,6,25 for 30-bus system

Measurement Type	Measurement locations
Voltage-magnitude buses	1, 6, 25
Voltage-angle buses	1, 6, 25
Current flow branches (real and reactive)	1-2, 1-3, 6-7, 6-8, 6-9, 6-10, 6-28, 25-26, 25-27

The type of PMU which is considered in this dissertation can provide the bus-voltage, phase-current and current phasors of all the connected lines if installed in a bus. This type of PMU is very widely used in the literature of PMU placement optimization and available in the market.

6.3 Comparison Between Heuristic Approach and Proposed GA based Approach

Chapter 4.5 presented a heuristic approach of PMU placement which aims to ensure the minimum estimation error. Because of having the common objective function, the heuristic technique has been compared with the proposed GA approach. The results of the optimal PMU locations along with their corresponding NCE values are prepared on IEEE 30-bus system with WLS estimator. The OPP results of comparison are arranged in Table 6.7 below.

Table 6.7 Comparison between GA vs Heuristic approach for 30-bus system using WLS

No. of PMUs		BGA	Heuristic
2	Buses with PMUs	1,6	1,6
	Indicator value	0.6536E-02	0.6536E-02
3	Buses with PMUs	1,6,25	1,10,25
	Indicator value	0.4236E-02	0.4514E-02
4	Buses with PMUs	1,6,12,24	1,6,25,22
	Indicator value	0.3400E-02	0.3544E-02
5	Buses with PMUs	1,24,25,28,12	1,6,25,22,12
	Indicator value	0.2672E-02	0.2787E-02

It can be observed that, placing two and five PMUs gave matched solutions for both algorithms. Optimal set of two, three and four PMUs of GA are different than heuristic approach. For both cases, GA provided error indicators are lower than heuristic and hence, it outperforms the heuristic approach. This happens because the heuristic technique places PMUs incrementally and it cannot change the PMU locations selected in previous steps when searching for new buses to be equipped with PMUs. BGA, on the other hand, does not have such restriction and always converges to the global solution.

Figure 6.1 shows how proposed approach with GA reaches the global solution for the optimal PMU set. Optimization for 5 PMUs for 30-bus system has been shown in the figure and it is seen that the fitness function, NCE indicator keeps decreasing until it finds the best set of PMUs with lowest indicator (0.2672E-02). Iteration stops at the maximum number of iterations which is 200.

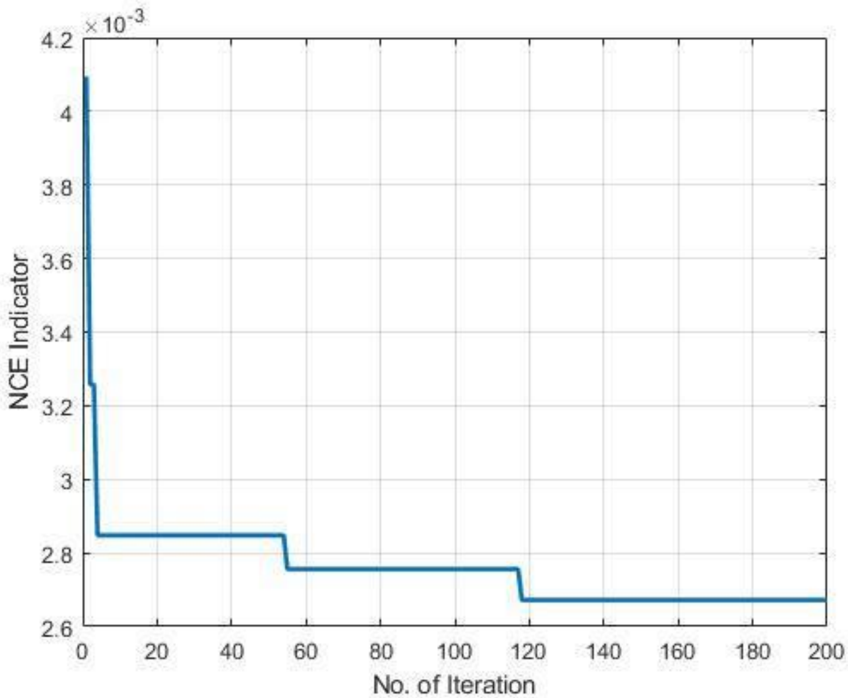

Figure 6.1 Convergence plot for 118-bus 6-PMUs placement

6.4 Significance of Covering the Critical Zone by PMU

The reason for imposing the constraint of placing PMUs in critical location is to reduce the impact of bad-data in estimation performance. In the practical power systems, bad-data could come from any location of the system. If it occurs in critical location or around it, the impact will be severe, and the estimation performance will be highly disturbed. Covering the critical location in PMU optimization will ensure that the bad-data presence, even around the critical location will not hamper the estimation performance of the system.

The optimal PMU locations with and without covering the critical zone are presented below in Table 6.8. Results are prepared with 30-bus test case for 2 to 5 number of PMUs with corresponding NCE values of WLS estimator.

Table 6.8 OPP results for 30-bus before and after covering critical zones

No. of PMUs		**NCC (Not Covering Critical)**	**CC (Covering Critical)**
2	Buses with PMUs	**1,6**	**1,12**
	Indicator value	**0.6536E-02**	**0.6610E-02**
3	Buses with PMUs	**1,10,25**	**1,12, 6**
	Indicator value	**0.4236E-02**	**0.5949E-02**
4	Buses with PMUs	1,6,12,24	1,6,12,24
	Indicator value	0.3400E-02	0.3408E-02
5	Buses with PMUs	1,6,25,22,12	1,6,25,22,12
	Indicator value	0.2787E-02	0.2787E-02

It can be observed from the Table 6.8, indicator value keeps decreasing with the increase of PMU number. For the sets with 2 and 3 PMUs, indicator values for CC are higher than NCC. It occurs because of the constraint of the optimization technique to cover the critical bus. The bus which covers the critical zone might not been included in global solution set given by NCC. For example, while placing 3 PMUs, solution set 1,10,25 is the global solution with lowest indicator 0.4236E-02. This optimal solution set is not achieved by CC because of forcing a PMU to install in critical bus-12. Optimization for placing 4 and 5 PMUs results same solution for both NCC and CC case. It reflects the solutions to be the global ones for both as the critical bus (bus-12) is included in the global solution set.

Table 6.9 shows the impact of bad-data presence around the critical measurements for both CC and NCC scenarios.

Table 6.9 Bad-data investigation with 3 PMU case of 30-bus (with WLS)

Cases	Bad-data location	NCC (Not Covering Critical) (PMUs in 1,10, 25	CC (Covering Critical) (PMUs in 1,6,12)
		NCE Indicator	NCE Indicator
White noises only	N/A	0.4236E-02	0.5949E-02
Bad-data presence	Vm_12	1.469E-02	0.5952E-02
	Q_15-12	1.4243E-02	0.6221E-02
	P_12-14	2.1768E-02	0.5907E-02
	P_12-16	4.0033E-02	0.5951E-02
	Q_12-14	0.5520E-02	0.5989E-02
	Q_12-16	0.4821E-02	0.6E-02

30-bus test system was having two critical measurements: P_12-13 and Q_12-13. That's why a PMU is placed in bus 12 to cover the critical zone. It is seen from the table that the estimation performance is better for NCC optimal set (1,10,25) than CC optimal set (1,6,12) without the presence of bad-data. But the presence of a single bad-data around bus 12 has completely changed the scenario. Six of such scenario has been presented in Table 28 where the location of bad-data is around the critical measurements. Because of the effect of bad-data, estimation performance for NCC deteriorates significantly and the error indicators reach to very high values. On the other hand, optimal location with CC shows robust behavior with bad-data due to the presence of one PMU in bus 12. The error indicator remains constant around 0.6E-02 for all the cases.

Even though the optimal solution by covering the critical zone is not always the global one, it is suggested to cover that to ensure the robustness of the estimation performance.

6.5 Optimization When the Critical measurements are Non-interacting

The 30-bus system test case used in this dissertation is having two critical measurements: P_12-13 and Q_12-13. Now, a modified test case is prepared for 30-bus system with much lower redundancy (1.74) which has the critical measurements in different zones of the system. The newly made test case has total of four critical measurements with two different critical zones. Two PMUs are needed now to cover the critical zones: 12 and 26. Therefore, three PMUs (1, 6, 12) are needed at least to cover the slack bus as well as the critical zones. While placing 2,4 and 5 PMUs, the solution will be the set with lowest NCE value among the possible combinations.

The optimization results for such a case is presented below in Table 6.10.

Table 6.10 OPP Results for 30-bus system with non-interacting critical measurements

Critical measurements	Elite chromosomes	Optimization Results		
		No of PMUs	Optimal PMU locations	NCE Indicator
P_12-13, Q_12-13, Q_25-26, Vm_26	1(slack bus), 12,26	2	1,12	0.6610E-02
		3	1, 12, 26	0.5989E-02
		4	1,6,12,26	0.4629E-02
		5	1,6,12,24,26	0.2596E-02

6.6 Optimal Number of PMUs

It has been discussed in the literature that the power system could be observable by only PMU meters with certain number of installed PMUs. For example, 4 PMUs in the optimal locations can make a 14-bus power system observable while it is needed to install 10 PMUs for 30-bus [69]. However, if the purpose of OPP is to install the PMUs in a SCADA measurement-based power system, it is difficult to conclude about the optimal number. Because, the inclusion of highly accurate PMU meters increases the efficiency of the estimator. More the PMUs are added, more the accuracy will be improved [80].

The optimization problem discussed in this dissertation tries to minimize the error indicator by placing the PMUs optimally. In case of adding an extra PMU in the SCADA-system, error indicator of the estimation process reduces, whatever the type of the estimator is. The decreasing pattern of NCE with PMU addition is presented in Figure 6.2for 30-bus system when the estimator is ULMR:

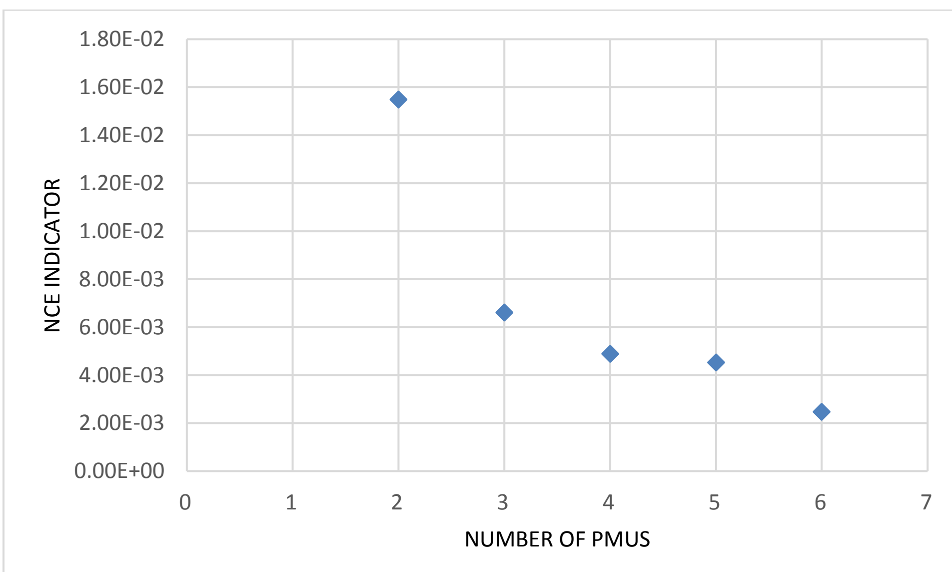

Figure 6.2 NCE vs number of PMUs for 30-bus system with ULMR estimator

However, the dissertation focuses on the optimal locations of the PMUs for any number of PMUs, not the optimal number of PMUs. The number of the PMUs to be installed will be decided by the utility, based on their plan.

6.7 Optimal PMU Locations with proposed Estimators

This chapter presents the OPP results for 14-, 30-, and 118-bus power systems when the power system is installed with the proposed estimators: HLMR and ULMR. Before placing the PMUs, the power system is considered observable with SCADA meters. The extra PMU meters will increase the overall redundancy. The optimization process will always place a PMU in the slack bus as well as will cover the critical measurements. The results for 14-bus system is presented below in Table 6.11.

Table 6.11 OPP results for 14-bus with proposed estimators

Number of PMUs	HLMR		ULMR	
	Optimal bus locations	NCE Indicator	Optimal bus locations	NCE Indicator
2	1,8	0.477E-02	1, 9	0.965E-02
3	1,3,8	0.304E-02	1, 2, 7	0.864E-02
4	1,3,9,12	0.159E-02	1, 2, 13, 14	0.845E-02

The 14-bus test case used in this dissertation is not having any critical measurement. Therefore, covering the bus-1 as the slack bus is the only elitism constraint which has been reflected in the solution sets by the proposed estimators. It is noticed that the NCE indicator decreases with the increase of PMU number. Besides, none of the solution set of HLMR matches with ULMR. Therefore, the optimal location of PMUs depends upon the type of the estimator. Results for 30-bus system is presented in Table 6.12.

Table 6.12 OPP results for 30-bus with proposed estimators

Number of PMUs	HLMR		ULMR	
	Optimal bus locations	**NCE Indicator**	**Optimal bus locations**	**NCE Indicator**
2	1,12	0.683E-02	1,12	1.548E-02
3	1,12,16	0.64E-02	1, 2, 12	0.661E-02
4	1,4,12,25	0.354E-02	1,12,18,19	0.488E-02
5	1,6,12,22,25	0.290E-02	1,2,12,6,24	0.452E-02
6	1,10,12,23,25,27	0.255E-02	1,2,6,12,24,28	0.247E-02

It is seen that the error indicator keeps decreasing with the increment of PMU number like before. Bus 1 and 12 are the automatic choices in the optimal set as they cover the slack bus and the critical measurements. Therefore, solution sets for placing 2 PMUs are same for both the estimators. But, for placing 3, 4, 5 and 6 number of PMUs in the system, HLMR resulted different solution set than ULMR.

Table 6.13 shows the optimal solution sets for 118-bus system whose slack bus is the 69th bus. However, the presence of critical measurements forces the optimization problem to place a PMU in bus-40 too. Therefore, bus 40 and 69 are included in each solution set for 118-bus system. Again, the NCE indicator kept decreasing with the increase of PMU number.

Table 6.13 OPP results for 118-bus with proposed estimators

Number of PMUs	HLMR		ULMR	
	Optimal bus locations	**NCE Indicator**	**Optimal bus locations**	**NCE Indicator**
2	40,69	2.02E-02	40,69	1.987E-02
3	40,68,69	1.643E-02	22,40,69	1.65E-02
4	4,40,68,69	1.51E-02	40,44,48,69	1.58E-02
5	17,103,40,68,69	1.281E-02	22,82,40,68,69	1.48E-02
6	40,68,69,28,99,100	1.258E-02	8,9,61,40,68,69	1.398E-02

6.8 Summary of the Optimization Results

This chapter presents a novel approach of PMU placement in power systems. Genetic algorithm is used to solve the proposed optimization problem which finds out the optimal set of any limited number of PMUs to be installed in a SCADA measurement-based power system.

The objective of the optimization problem is to guarantee the best performance of state estimation process. It also ensures covering of the critical zones by PMUs and thus confirms the least impact of bad-data presence in the estimation performance.

The proposed method is compared with a heuristic approach presented in the literature. However, it is seen that the GA-based approach outperforms the heuristic approach in several cases. Some of the optimal solution sets are found identical for both approaches indicating that both techniques reached the global solution.

Covering the critical locations is one of the distinct features of proposed OPP which results a solution set, less sensitive to bad-data presence.

In the practical scenarios where the modern-day power systems are inclining towards installing PMU meters with the existing system, such a strategy of getting the most optimal locations for any limited number of PMUs would be very useful and effective for planning engineers.

The objective of the dissertation was to contribute in the field of power system protection, monitoring and control. This can be achieved in two ways: by using appropriate robust state estimators and by using the PMUs in the power systems after placing them optimally in the system. The dissertation proposed two estimators: HLMR and ULMR, which has been found significantly robust under bad-data occurrence. In the field of PMU placement, the major contribution was to get the optimal set of PMUs which will ensure the minimum estimation loss. The optimization technique is applicable to get any limited number of PMUs in the SCADA-based power systems and applicable to use with any estimator. The following flow diagram (Figure 6.3) summarizes the whole dissertation where the contributions are highlighted:

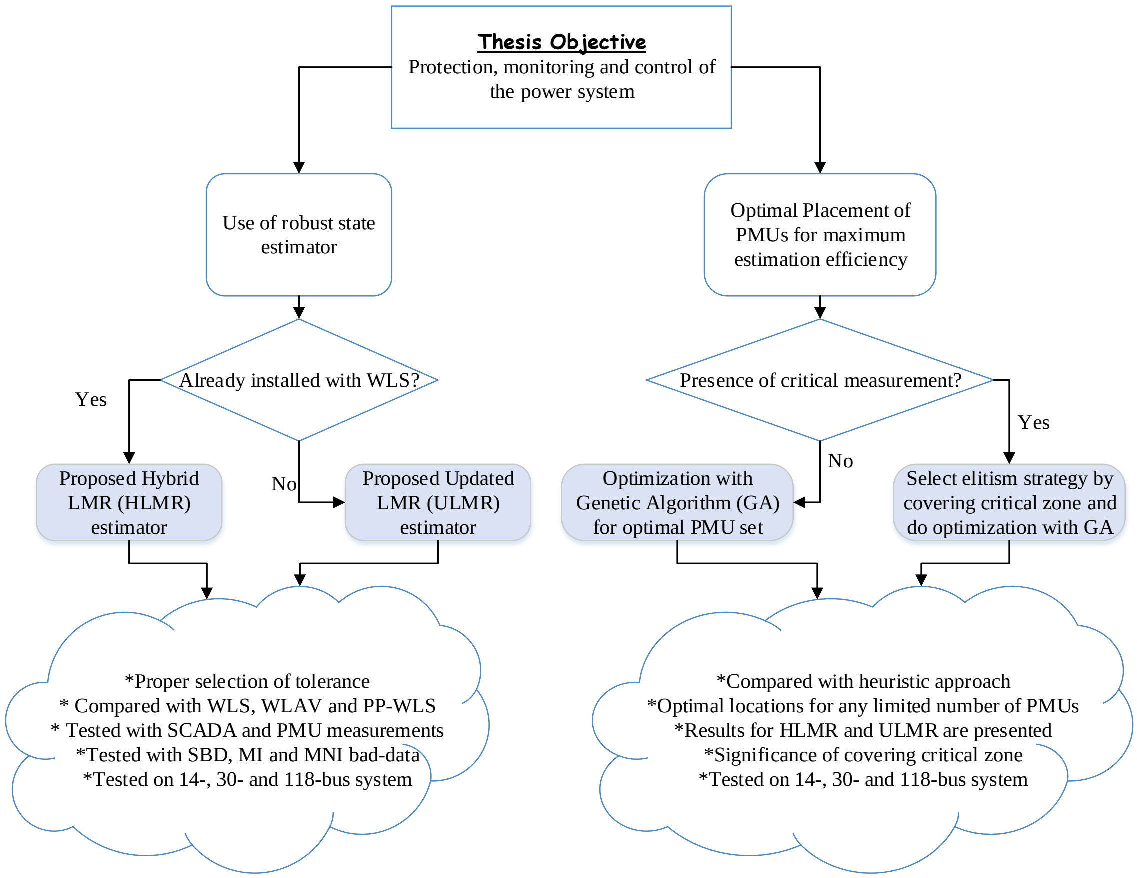

Figure 6.3 Summary of the dissertation

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 Dissertation Conclusions

This dissertation presented a successful development of two robust estimator versions that can filter out single as well as multiple bad-data accurately and efficiently. If the energy management system (EMS) is already installed with WLS estimator, the proposed robust HLMR estimator could be a fruitful replacement. This version of estimator is inspired from the combination of both WLS and LMR estimators. For the scenario of installing a new estimator in the power system, the ULMR robust estimator is suggested. Both estimator versions were developed by introducing novel approaches in selecting the appropriate tolerance in the LMR formulation. The proposed estimators are found highly accurate during the estimation process and robust in dealing with different bad-data scenarios. The performance of the two robust estimators have been investigated successfully with well-known estimators: WLS and WLAV.

In the field of PMU placement, this dissertation presented a novel approach to find the optimal locations for any selected number of PMU's to be installed in a SCADA-measurement power system. Genetic algorithm (GA), a well-known intelligent technique, is used to find the optimal location. This approach might be very helpful for the planning engineers in a power utility to determine the optimal bus locations to be equipped with

PMUs when they have a limited number of them. The performance of estimation process has been also investigated when placing of PMU's in critical bus locations. It has been observed that such selection would improve the estimated estates when bad-data are present.

7.2 Future Works

There are lots of scopes to carry on the research further on the field of power system state estimation and optimal PMU placement. Some of potential future works are pointed here.

1. The proposed estimators, ULMR and HLMR are compared with WLS, WLAV and post-processed WLS in this dissertation. There are several other estimators proposed in the literature. To compare the proposed estimators with other robust estimators could be a future work.

2. 14-, 30-, and 118-bus test cases are used in this dissertation to check the robustness of the proposed estimators. They can be checked and tested in larger power systems and in the practical grid systems.

3. To test the proposed estimators in the distribution network of the power system.

4. The static state estimation process is presented throughout the whole dissertation work. To modify the proposed estimators for dynamic estimation could be an important future work.

5. As a very well-known and efficient technique of intelligent optimization, Genetic Algorithm (GA) is used in this dissertation to solve the PMU placement optimization. It

can be considered as a future work to implement the proposed optimization procedure of PMU placement by other optimization techniques.

6. To add more constraints to the optimization problem formulation like contingency analysis, adding channel limit, using other types of PMUs, considering the cost analysis and so on can be an effective option for future work.

7. Faster reporting rate of PMU than SCADA system is one of the major challenges of including synchronized phasor measurements into the SCADA based estimation process. It can be resolved by designing an optimal buffer system. It can be a wide field of further research.

8. Gaussian distribution errors are considered in generating the measurement series of SCADA. Practically it's not always true and the further research can be made to check the proposed techniques with non-Gaussian error distribution.

9. Redundancy level of available meter readings plays a key role in the performance of any estimator. A detail analysis could be carried on in future to investigate the impact of different redundancy level on the proposed estimator.

7.3 Publications from the Dissertation Work

7.3.1 Published Journal Articles

[1] **M. Shahriar**, I. Habiballah, and H. Hussein, "Optimization of Phasor Measurement Unit (PMU) Placement in Supervisory Control and Data Acquisition (SCADA)-Based Power System for Better State-Estimation Performance," Energies 2018, vol. 11, no. 3, p. 570, Mar. 2018. DOI: 10.3390/en11030570

7.3.2 Accepted Conference Papers/ Posters

[1] **M. Shoaib Shahriar**, F. A. Ahmad, I. O. Habiballah, M. A. Asif, and S. Mukherjee, “Artificial Bee Colony based OPimal PMU Placement in Power System State Estimation.” 1st International Conference on Advanced Information and Communication Technology (ICAICT 2016), May 16-17, 2016, Chittagong, Bangladesh. **(Got the best paper award)**

[2] **M. Shoaib Shahriar**, I. O. Habiballah “ Least Measurement Rejected Algorithm for Robust Power System State Estimation,” The 7th Innovative Smart Grid Technologies (ISGT Asia 2017) Conference, December 4-7, 2017, Auckland, New Zealand. **(IEEE Flagship Conference)**

[3] **M. Shoaib Shahriar**, I. O. Habiballah, F. A. Ahmad, M. A. Asif “Artificial Bee Colony based OPimal PMU Placement in Power System State Estimation.” International Conference on Electrical, Electronics, Computers, Communication, Mechanical and Computing (EECCMC), January 28-29, 2018, Vellore, India. **(IEEE Flagship Conference)**

[4] F. A. Ahmad, **M. Shoaib Shahriar**, I. O. Habiballah “State Estimation accuracy of tuned Least Measurement Rejection estimator,” International Conference on Electrical Engineering (ICEE), February 15-16, 2018, Lahore, Pakistan. **(IEEE Flagship Conference)**

[5] **M. Shoaib Shahriar**, I. O. Habiballah “Incorporation of current phasors in Least Measurement Rejected (LMR) Algorithm,” Saudi Arabia Smart Grid (SASG 2017) Conference, December 12-14, 2017, Jeddah, Saudi Arabia. **(Poster)**

References

[1] A. J. Wood, B. F. Wollenberg, and G. B. Sheblé, *Power generation, operation, and control*. .

[2] F. Schweppe, “Power System Static-State Estimation, Part III: Implementation,” *IEEE Trans. Power Appar. Syst.*, vol. PAS-89, no. 1, pp. 130–135, Jan. 1970.

[3] F. Schweppe and J. Wildes, “Power System Static-State Estimation, Part I: Exact Model,” *IEEE Trans. Power Appar. Syst.*, vol. PAS-89, no. 1, pp. 120–125, Jan. 1970.

[4] H. M. Rustebakke and General Electric Company. Electric Utility Systems Engineering Department., *Electric utility systems and practices*. Wiley, 1983.

[5] R. H. (Robert H. Miller and J. H. Malinowski, *Power system operation*. McGraw-Hill, 1994.

[6] Institute of Electrical and Electronics Engineers., J. Radatz, and IEEE Computer Society. Standards Coordinating Committee., *The IEEE standard dictionary of electrical and electronics terms*. Institute of Electrical and Electronics Engineers, 1997.

[7] J. Chen, “Power System State Estimation Using Phasor Measurement Units,” *Theses Diss. Comput. Eng.*, Jan. 2013.

[8] A. Monticelli, “Electric power system state estimation,” *Proc. IEEE*, vol. 88, no. 2, pp. 262–282, Feb. 2000.

[9] A. G. Phadke, “Synchronized phasor measurements in power systems,” *IEEE Comput. Appl. Power*, vol. 6, no. 2, pp. 10–15, Apr. 1993.

[10] A. G. Phadke and J. S. (John S. Thorp, *Synchronized phasor measurements and their applications*. .

[11] L. Zhao and A. Abur, “Multiarea State Estimation Using Synchronized Phasor Measurements,” *IEEE Trans. Power Syst.*, vol. 20, no. 2, pp. 611–617, May 2005.

[12] A. Abur, A. Abur, and P. Rousseaux, “On the Use of PMUs in Power System State Estimation.”

[13] T. L. Baldwin, L. Mili, M. B. Boisen, and R. Adapa, “Power system observability

with minimal phasor measurement placement," *IEEE Trans. Power Syst.*, vol. 8, no. 2, pp. 707–715, May 1993.

[14] A. Abur and A. G. Expósito, *Power System State Estimation: Theory and Implementation*. CRC Press, 2004.

[15] "Power system state estimation using an iteratively reweighted least squares method for sequential L1-regression," *Int. J. Electr. Power Energy Syst.*, vol. 28, no. 2, pp. 86–92, Feb. 2006.

[16] A. S. Debs, *Modern Power Systems Control and Operation*. Boston, MA: Springer US, 1988.

[17] Huthaifa Mahmoud Abedalaziz Hussein, "Optimal placement of PMUs for enhancing power system state estimation including both V & I phasors," King Fahd university of petroleum & minerals Dhahran- 31261, Saudi Arabia, 2017.

[18] S. M. Mahaei and M. R. Navayi, "Power System State Estimation with Weighted Linear Least Square," vol. 4, no. 2, 2014.

[19] S. O. Orero, "A genetic algorithm for network partitioning in power system state estimation," in *UKACC International Conference on Control. Control '96*, 1996, vol. 1996, pp. 162–165.

[20] D. H. Tungadio, B. P. Numbi, M. W. Siti, and J. A. Jordaan, "Weighted least squares and iteratively reweighted least squares comparison using Particle Swarm Optimization algorithm in solving power system state estimation," in *2013 Africon*, 2013, pp. 1–6.

[21] F. Zhuang and R. Balasubramanian, "Bad Data Suppression in Power System State Estimation with a Variable Quadratic-Constant Criterion," *IEEE Trans. Power Appar. Syst.*, vol. PAS-104, no. 4, pp. 857–863, Jul. 1985.

[22] R. A. Jabr, "Power system Huber M-estimation with equality and inequality constraints," *Electr. Power Syst. Res.*, vol. 74, no. 2, pp. 239–246, 2005.

[23] R. Baldick, K. A. Clements, Z. Pinjo-Dzigal, and P. W. Davis, "Implementing nonquadratic objective functions for state estimation and bad data rejection," *IEEE Trans. Power Syst.*, vol. 12, no. 1, pp. 376–382, 1997.

[24] H. Singh and F. L. Alvarado, "Weighted Least Absolute Value state estimation using interior point methods," *IEEE Trans. Power Syst.*, vol. 9, no. 3, pp. 1478–1484, 1994.

[25] R. A. Jabr and B. C. Pal, "Iteratively reweighted least-squares implementation of the WLAV state-estimation method," *IEE Proc. - Gener. Transm. Distrib.*, vol. 151, no. 1, p. 103, 2004.

[26] M. Gol and A. Abur, "LAV Based Robust State Estimation for Systems Measured by PMUs," *IEEE Trans. Smart Grid*, vol. 5, no. 4, pp. 1808–1814, Jul. 2014.

[27] A. Abur and M. K. Celik, "A fast algorithm for the weighted least absolute value state estimation (for power systems)," *IEEE Trans. Power Syst.*, vol. 6, no. 1, pp. 1–8, 1991.

[28] Muhammad Faraz Sahito, "Power system State Estimation using Phasor Measurement Units," KING FAHAD UNIVERSITY OF PETROLEUM AND MINERALS DHAHRAN, SAUDI ARABIA, 2015.

[29] P. J. Huber and E. Ronchetti, *Robust statistics*. Wiley, 2009.

[30] P. J. Rousseeuw, "Least Median of Squares Regression," *J. Am. Stat. Assoc.*, vol. 79, no. 388, pp. 871–880, Dec. 1984.

[31] Weiqing Jiang, V. Vittal, and G. T. Heydt, "Diakoptic State Estimation Using Phasor Measurement Units," *IEEE Trans. Power Syst.*, vol. 23, no. 4, pp. 1580–1589, Nov. 2008.

[32] H. Maalouf, R. A. Jabr, and M. Awad, "Mixed-integer Quadratic Programming Based Rounding Technique for Power System State Estimation with Discrete and Continuous Variables," *Electr. Power Components Syst.*, vol. 41, no. 5, pp. 555–567, Mar. 2013.

[33] M. R. Irving, "Robust State Estimation Using Mixed Integer Programming," *IEEE Trans. Power Syst.*, vol. 23, no. 3, pp. 1519–1520, Aug. 2008.

[34] I. O. Habiballah, "Robust estimators using mathematical programming algorithms," in *2012 IEEE International Conference on Power System Technology (POWERCON)*, 2012, pp. 1–6.

[35] M. R. Irving, "A tutorial introduction to robust estimators with mathematical programming solutions," 2008.

[36] E. Caro and A. J. Conejo, "State estimation via mathematical programming: a comparison of different estimation algorithms," *IET Gener. Transm. Distrib.*, vol. 6, no. 6, p. 545, 2012.

[37] M. R. Irving, "Robust Algorithm for Generalized State Estimation," *IEEE Trans. Power Syst.*, vol. 24, no. 4, pp. 1886–1887, Nov. 2009.

[38] Xia Yuanhai, "Robust estimators in modern power system networks," King fahd University of Petroleum and Minerals, Dhahran, saudi Arabia, 2013.

[39] M. R. Irving, "Robust State Estimation Using Mixed Integer Programming," *IEEE Trans. Power Syst.*, vol. 23, no. 3, pp. 1519–1520, Aug. 2008.

[40] FARHAN AHMAD, "Performance of state estimators incorporating voltage and current phasors from PMU," King Fahd University of Petroleum and Minerals., 2017.

[41] F. Aminifar, M. Shahidehpour, M. Fotuhi-Firuzabad, and S. Kamalinia, "Power system dynamic state estimation with synchronized phasor measurements," *IEEE Trans. Instrum. Meas.*, vol. 63, no. 2, pp. 352–363, 2014.

[42] C. Hernandez and P. Maya-Ortiz, "Comparison between WLS and Kalman Filter method for power system static state estimation," in *2015 International Symposium on Smart Electric Distribution Systems and Technologies (EDST)*, 2015, pp. 47–52.

[43] Y. CHEN and J. MA, "A mixed-integer linear programming approach for robust state estimation," *J. Mod. Power Syst. Clean Energy*, vol. 2, no. 4, pp. 366–373, Dec. 2014.

[44] G. He, S. Dong, J. Qi, and Y. Wang, "Robust State Estimator Based on Maximum Normal Measurement Rate," *IEEE Trans. Power Syst.*, vol. 26, no. 4, pp. 2058–2065, Nov. 2011.

[45] Y. Chen, J. Ma, P. Zhang, F. Liu, and S. Mei, "Robust State Estimator Based on Maximum Exponential Absolute Value," *IEEE Trans. Smart Grid*, vol. 8, no. 4, pp. 1537–1544, Jul. 2017.

[46] Y. Chakhchoukh, V. Vittal, G. T. Heydt, and H. Ishii, "LTS-Based Robust Hybrid SE Integrating Correlation," *IEEE Trans. Power Syst.*, vol. 32, no. 4, pp. 3127–3135, Jul. 2017.

[47] B. Milosevic and M. Begovic, "Nondominated sorting genetic algorithm for optimal phasor measurement placement," *IEEE Trans. Power Syst.*, vol. 18, no. 1, pp. 69–

75, Feb. 2003.
[48] R. F. Nuqui and A. G. Phadke, “Phasor Measurement Unit Placement Techniques for Complete and Incomplete Observability,” *IEEE Trans. Power Deliv.*, vol. 20, no. 4, pp. 2381–2388, Oct. 2005.
[49] A. Abur, “Observability analysis and measurement placement for systems with PMUs,” in *IEEE PES Power Systems Conference and Exposition, 2004.*, 2004, pp. 1472–1475.
[50] “Electric Power System Applications of Optimization, Second Edition - CRC Press Book.” [Online]. Available: https://www.crcpress.com/Electric-Power-System-Applications-of-Optimization-Second-Edition/Momoh/9781420065862. [Accessed: 17-Apr-2016].
[51] S. Chakrabarti and E. Kyriakides, “Optimal Placement of Phasor Measurement Units for Power System Observability,” *IEEE Trans. Power Syst.*, vol. 23, no. 3, pp. 1433–1440, Aug. 2008.
[52] D. Dua, S. Dambhare, R. K. Gajbhiye, and S. A. Soman, “Optimal Multistage Scheduling of PMU Placement: An ILP Approach,” *IEEE Trans. Power Deliv.*, vol. 23, no. 4, pp. 1812–1820, Oct. 2008.
[53] J. Peng, Y. Sun, and H. F. Wang, “Optimal PMU placement for full network observability using Tabu search algorithm,” *Int. J. Electr. Power Energy Syst.*, vol. 28, no. 4, pp. 223–231, May 2006.
[54] C. Peng, H. Sun, and J. Guo, “Multi-objective optimal PMU placement using a non-dominated sorting differential evolution algorithm,” *Int. J. Electr. Power Energy Syst.*, vol. 32, no. 8, pp. 886–892, Oct. 2010.
[55] M. Hurtgen and J.-C. Maun, “Optimal PMU placement using Iterated Local Search,” *Int. J. Electr. Power Energy Syst.*, vol. 32, no. 8, pp. 857–860, Oct. 2010.
[56] R. Sodhi, S. C. Srivastava, and S. N. Singh, “Optimal PMU placement method for complete topological and numerical observability of power system,” *Electr. Power Syst. Res.*, vol. 80, no. 9, pp. 1154–1159, Sep. 2010.
[57] A. Ahmadi, Y. Alinejad-Beromi, and M. Moradi, “Optimal PMU placement for power system observability using binary particle swarm optimization and considering measurement redundancy,” *Expert Syst. Appl.*, vol. 38, no. 6, pp. 7263–7269, Jun. 2011.
[58] M. Hajian, A. M. Ranjbar, T. Amraee, and B. Mozafari, “Optimal placement of PMUs to maintain network observability using a modified BPSO algorithm,” *Int. J. Electr. Power Energy Syst.*, vol. 33, no. 1, pp. 28–34, Jan. 2011.
[59] C. Rakpenthai, S. Premrudeepreechacharn, S. Uatrongjit, and N. R. Watson, “An Optimal PMU Placement Method Against Measurement Loss and Branch Outage,” *IEEE Trans. Power Deliv.*, vol. 22, no. 1, pp. 101–107, Jan. 2007.
[60] S. Chakrabarti and E. Kyriakides, “Optimal Placement of Phasor Measurement Units for Power System Observability,” *IEEE Trans. Power Syst.*, vol. 23, no. 3, pp. 1433–1440, Aug. 2008.
[61] K. Jamuna and K. S. Swarup, “Optimal placement of PMU and SCADA measurements for security constrained state estimation,” *Int. J. Electr. Power Energy Syst.*, vol. 33, no. 10, pp. 1658–1665, Dec. 2011.
[62] A. Mahari and H. Seyedi, “Optimal PMU placement for power system observability using BICA, considering measurement redundancy,” *Electr. Power Syst. Res.*, vol.

103, pp. 78–85, Oct. 2013.
[63] M. H. F. Wen and V. O. K. Li, “Optimal PMU placement for wide-area monitoring using chemical reaction optimization,” in *2013 IEEE PES Innovative Smart Grid Technologies Conference (ISGT)*, 2013, pp. 1–6.
[64] S. M. Mazhari, H. Monsef, H. Lesani, and A. Fereidunian, “A Multi-Objective PMU Placement Method Considering Measurement Redundancy and Observability Value Under Contingencies,” *IEEE Trans. Power Syst.*, vol. 28, no. 3, pp. 2136–2146, Aug. 2013.
[65] Z. Hui-Ling, D. Yuan-Xiu, Z. Xiao-Pan, Q. Huan, and H. Cheng-Xun, “Hybrid of MST and Genetic Algorithm on Minimizing PMU Placement,” in *2013 Third International Conference on Intelligent System Design and Engineering Applications*, 2013, pp. 820–823.
[66] T. K. and W. Ongsakul, “Optimal Placement of PMU and RTU by Hybrid Genetic Algorithm and Simulated Annealing for Multiarea Power System State Estimation.” Rajamangala University of Technology Thanyaburi Faculty of Engineering, 2009.
[67] K. Mazlumi and H. Vahedi, “Optimal placement of PMUs in power systems based on bacterial foraging algorithm,” in *2010 18th Iranian Conference on Electrical Engineering*, 2010, pp. 885–888.
[68] S. M. Aminifar F, Fotuhi-Firuzabad M, Safdarian A, “Observability of hybrid AC/DC power systems with variable-cost PMUs,” *IEEE Trans Power Deliv.*, vol. 29, pp. 345–352, 2014.
[69] M. Shoaib Shahriar, F. A. Ahmad, I. O. Habiballah, M. A. Asif, and S. Mukherjee, “Artificial Bee Colony based Optimal PMU Placement in Power System State Estimation,” in *1st International Conference on Advanced Information and Communication Technology 2016 (ICAICT 2016)*, 2016.
[70] A. Tarali and A. Abur, “Bad data detection in two-stage state estimation using phasor measurements,” in *2012 3rd IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe)*, 2012, pp. 1–8.
[71] M. Gol and A. Abur, “PMU placement for robust state estimation,” in *2013 North American Power Symposium (NAPS)*, 2013, pp. 1–5.
[72] J. Wu, J. Xiong, P. Shil, and Y. Shi, “Optimal PMU placement for identification of multiple power line outages in smart grids,” in *2014 IEEE 57th International Midwest Symposium on Circuits and Systems (MWSCAS)*, 2014, pp. 354–357.
[73] J. Zhu and A. Abur, “Bad Data Identification When Using Phasor Measurements,” in *2007 IEEE Lausanne Power Tech*, 2007, pp. 1676–1681.
[74] A. Abur, “Improved bad data processing via strategic placement of PMUs,” in *IEEE Power Engineering Society General Meeting, 2005*, 2005, pp. 2759–2763.
[75] Z. Lu, S. Tian, X. Liu, and H. Zhao, “A new numerical algorithm to check the observability and bad-data processing ability of the metering scheme,” *Int. J. Electr. Power Energy Syst.*, vol. 66, pp. 144–153, Mar. 2015.
[76] R. Emami, A. Abur, and F. Galvan, “Optimal placement of phasor measurements for enhanced state estimation: A case study,” *Proc. 16th PSCC, Glas. …*, 2008.
[77] B. Gou and R. G. Kavasseri, “Unified PMU Placement for Observability and Bad Data Detection in State Estimation,” *IEEE Trans. Power Syst.*, vol. 29, no. 6, pp. 2573–2580, Nov. 2014.
[78] J. Chen and A. Abur, “Placement of PMUs to Enable Bad Data Detection in State

Estimation," *IEEE Trans. Power Syst.*, vol. 21, no. 4, pp. 1608–1615, Nov. 2006.

[79] S. Chakrabarti, E. Kyriakides, G. Ledwich, and A. Ghosh, "Inclusion of PMU current phasor measurements in a power system state estimator," *IET Gener. Transm. Distrib.*, vol. 4, no. 10, p. 1104, 2010.

[80] M. Shahriar, I. Habiballah, and H. Hussein, "Optimization of Phasor Measurement Unit (PMU) Placement in Supervisory Control and Data Acquisition (SCADA)-Based Power System for Better State-Estimation Performance," *Energies 2018, Vol. 11, Page 570*, vol. 11, no. 3, p. 570, Mar. 2018.

[81] K. Zhu, L. Nordstrom, and L. Ekstam, "Application and analysis of optimum PMU placement methods with application to state estimation accuracy," in *2009 IEEE Power & Energy Society General Meeting*, 2009, pp. 1–7.

[82] K. Negash, B. Khan, and E. Yohannes, "Artificial Intelligence Versus Conventional Mathematical Techniques: A Review for Optimal Placement of Phasor Measurement Units," *Technol. Econ. Smart Grids Sustain. Energy*, vol. 1, no. 1, p. 10, Dec. 2016.

[83] J. Chen and Y. Liao, "Investigation of WLS state estimation convergence under topology errors and load increment," *Int. J. Autom. Logist.*, vol. 1, no. 1, p. 47, 2013.

[84] M. A. Rahman and G. K. Venayagamoorthy, "Convergence of the Fast State Estimation for Power Systems."

[85] A. Abur and M. K. Celik, "Least absolute value state estimation with equality and inequality constraints," *IEEE Trans. Power Syst.*, vol. 8, no. 2, pp. 680–686, May 1993.

[86] H. Singh and F. L. Alvarado, "Weighted Least Absolute Value state estimation using interior point methods," *IEEE Trans. Power Syst.*, vol. 9, no. 3, pp. 1478–1484, 1994.

[87] A. Abur, "A bad data identification method for linear programming state estimation," *IEEE Trans. Power Syst.*, vol. 5, no. 3, pp. 894–901, 1990.

[88] S. Mahdi Mahaei and M. Reza Navayi, "Power System State Estimation with Weighted Linear Least Square," *Int. J. Electr. Comput. Eng. J.*, vol. 4, no. 2, pp. 2088–8708, 2014.

[89] T. S. Bi, X. H. Qin, and Q. X. Yang, "A novel hybrid state estimator for including synchronized phasor measurements," *Electr. Power Syst. Res.*, vol. 78, no. 8, pp. 1343–1352, 2008.

[90] "Optimal PMU placement using topology transformation method in power systems," *J. Adv. Res.*, vol. 7, no. 5, pp. 625–634, Sep. 2016.

[91] F. Wu and A. Monticelli, "Network Observability: Theory," *IEEE Trans. Power Appar. Syst.*, vol. PAS-104, no. 5, pp. 1042–1048, May 1985.

[92] T. L. Baldwin, L. Mili, M. B. Boisen, and R. Adapa, "Power system observability with minimal phasor measurement placement," *IEEE Trans. Power Syst.*, vol. 8, no. 2, pp. 707–715, May 1993.

[93] J. B. A. London, L. F. C. Alberto, and N. G. Bretas, "Network observability: identification of the measurements redundancy level," in *PowerCon 2000. 2000 International Conference on Power System Technology. Proceedings (Cat. No.00EX409)*, vol. 2, pp. 577–582.

[94] M. B. Do Coutto Filho, J. C. Stacchini de Souza, F. M. F. de Oliveira, and M. T. Schilling, "Identifying critical measurements & sets for power system state

estimation," in *2001 IEEE Porto Power Tech Proceedings (Cat. No.01EX502)*, vol. vol.3, p. 6.

[95] X. Nan and G. H. Beng, "Optimal PMU placement with local redundancy of conventional measurements," in *2013 IEEE Computational Intelligence Applications in Smart Grid (CIASG)*, 2013, pp. 1–5.

[96] A. Al-atwan and H.-J. Koglin, "Two aspects of local redundancy in state estimation," *IEE Proc. - Gener. Transm. Distrib.*, vol. 145, no. 4, p. 458, 1998.

[97] A. Z. Gamm, I. N. Kolosok, and A. M. Glazunova, "Test equations for validation of critical measurements and critical sets at power system state estimation," in *2005 IEEE Russia Power Tech*, 2005, pp. 1–6.

[98] R. Kumar and D. Prasad, "Effect of bad measurements on state estimation in power system," in *2012 IEEE Fifth Power India Conference*, 2012, pp. 1–5.

[99] G. Adolfo and V. Mora, "UNCERTAINTY AND STATE ESTIMATION OF POWER SYSTEMS," 2012.

[100] B. Gou and R. G. Kavasseri, "Unified PMU Placement for Observability and Bad Data Detection in State Estimation," *IEEE Trans. Power Syst.*, vol. 29, no. 6, pp. 2573–2580, Nov. 2014.

[101] L. M. Schmitt, "Theory of genetic algorithms," *Theor. Comput. Sci.*, vol. 259, no. 1–2, pp. 1–61, May 2001.

[102] C. R. Houck, C. R. Houck, J. A. Joines, and M. G. Kay, "A Genetic Algorithm for Function Optimization: A Matlab Implementation," 1996.

[103] M. B. Do Coutto Filho, J. C. Stacchini de Souza, F. M. F. de Oliveira, and M. T. Schilling, "Identifying critical measurements & sets for power system state estimation," in *2001 IEEE Porto Power Tech Proceedings (Cat. No.01EX502)*, vol. vol.3, p. 6.

[104] M. Shahriar, I. Habiballah, and H. Hussein, "Optimization of Phasor Measurement Unit (PMU) Placement in Supervisory Control and Data Acquisition (SCADA)-Based Power System for Better State-Estimation Performance," *Energies 2018, Vol. 11, Page 570*, vol. 11, no. 3, p. 570, Mar. 2018.

[105] J. Chen and Y. Liao, "Optimal Placement of Phasor Measurement Units for Improving Power System State Estimation Accuracy: A Heuristic Approach," *J. Electr. Eng. Electron. Technol.*, vol. 1, no. 1, Oct. 2012.

[106] Srinath Kamireddy, "Comparison of State Estimation Algorithms Considering Phasor Measurement ... - Srinath Kamireddy - Google Books," 2008. .

[107] A. Monticelli and A. Garcia, "Reliable Bad Data Processing for Real-Time State Estimation," *IEEE Trans. Power Appar. Syst.*, vol. PAS-102, no. 5, pp. 1126–1139, May 1983.

[108] M. Gol and A. Abur, "LAV Based Robust State Estimation for Systems Measured by PMUs," *IEEE Trans. Smart Grid*, vol. 5, no. 4, pp. 1808–1814, Jul. 2014.

[109] Y. Lin and A. Abur, "Highly Efficient Implementation for Parameter Error Identification Method Exploiting Sparsity," *IEEE Trans. Power Syst.*, vol. 32, no. 1, pp. 734–742, Jan. 2017.

[110] P. Bajpai and D. M. Kumar, "Genetic Algorithm – an Approach to Solve Global Optimization Problems," *Indian J. Comput. Sci. Eng.*, vol. 1, no. 3, pp. 199–206.

[111] R. F. Nuqui and A. G. Phadke, "Hybrid Linear State Estimation Utilizing Synchronized Phasor Measurements," in *2007 IEEE Lausanne Power Tech*, 2007,

pp. 1665–1669.
[112] M. (Computer scientist) Mitchell, *An introduction to genetic algorithms*. MIT Press, 1996.

APPENDIX A

IEEE STANDARD POWER SYSTEMS

A.1. 14-Bus System Details

A.1.1. Single Line Diagram

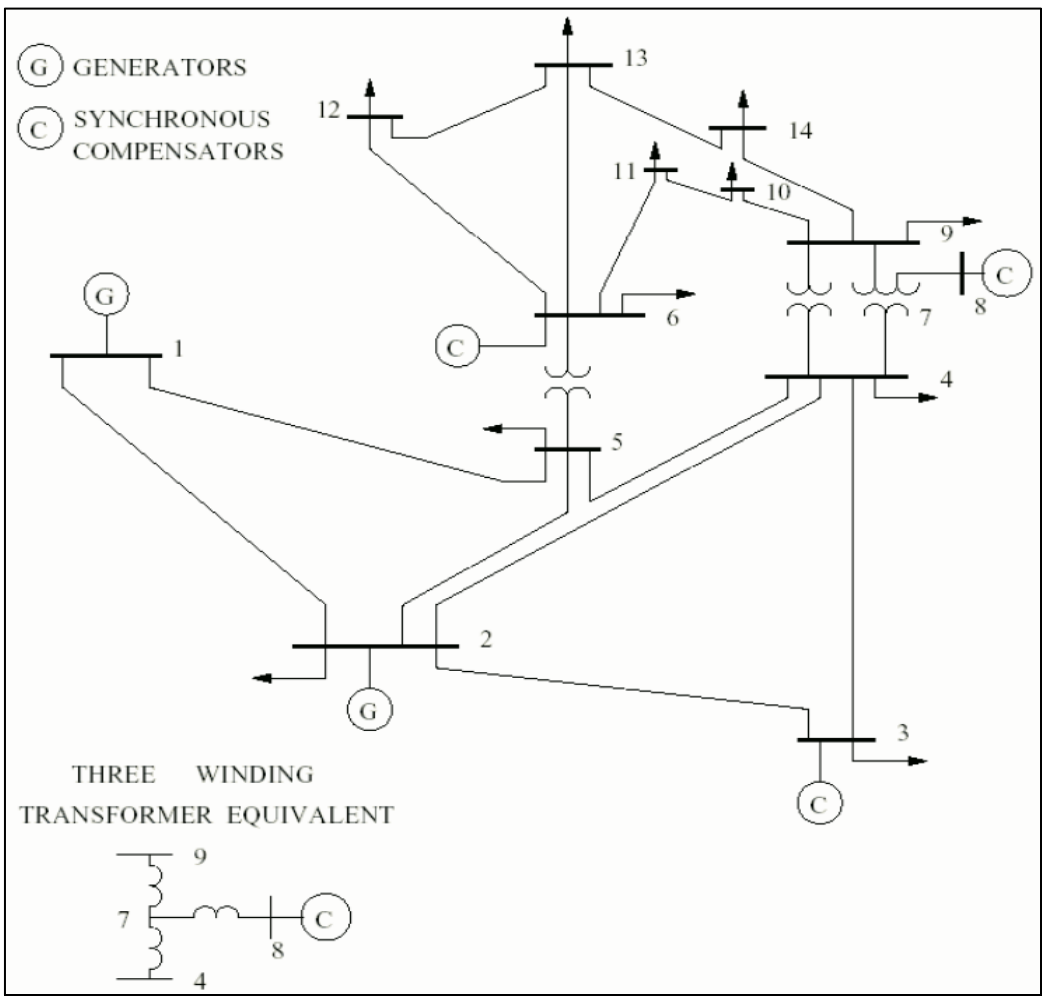

Figure A.1 Single Line Diagram of IEEE 14-bus power system [98]

A.1.2. Line Data

Table A.1 Line Data details of IEEE 14-Bus System

From Bus	To Bus	R	X	B	Tap Setting
1	2	0.01938	0.05917	0.0528	0
1	5	0.05403	0.22304	0.0492	0
2	3	0.04699	0.19797	0.0438	0
2	4	0.05811	0.17632	0.034	0
2	5	0.05695	0.17388	0.0346	0
3	4	0.06701	0.17103	0.0128	0
4	5	0.01335	0.04211	0	0
4	7	0	0.20912	0	0.978
4	9	0	0.55618	0	0.969
5	6	0	0.25202	0	0.932
6	11	0.09498	0.1989	0	0
6	12	0.12291	0.25581	0	0
6	13	0.06615	0.13027	0	0
7	8	0	0.17615	0	0
7	9	0	0.11001	0	0
9	10	0.03181	0.0845	0	0
9	14	0.12711	0.27038	0	0
10	11	0.08205	0.19207	0	0
12	13	0.22092	0.19988	0	0
13	14	0.17093	0.34802	0	0

A.1.3. Bus Data

Table A.2 Bus Data details of IEEE 14-Bus System

Sr	Bus Type	|V|	Generation		Load		Generation Limits	
			MW	MAVR	MW	MAVR	Max	Min
1	3	1.06	232.39	-16.549	0	0	0	0
2	2	1.045	40	43.55	21.7	12.7	50	-40
3	2	1.01	0	25.07	94.2	19	40	0
4	1	1.018	0	0	47.8	-3.9	-	-
5	1	1.02	0	0	7.6	1.6	-	-
6	2	1.07	0	12.73	11.2	7.5	24	-6
7	1	1.062	0	0	0	0	-	-
8	2	1.09	0	17.62	0	0	24	-6
9	1	1.056	0	0	29.5	16.6	-	-
10	1	1.051	0	0	9	5.8	-	-
11	1	1.057	0	0	3.5	1.8	-	-

12	1	1.055	0	0	6.1	1.6	-	-
13	1	1.05	0	0	13.5	5.8	-	-
14	1	1.036	0	0	14.9	5	-	-

A.1.4. Load Flow Solution and Corresponding Measurement Values

Table 0.3 Load Flow and Simulated Measurement values for 14-bus System

Type	Index	Actual	Measurement	Type	Index	Actual	Measurement
V1	1	1.06E+00	1.06E+00	P13-14	20	5.64E-02	5.56E-02
V2	2	1.05E+00	1.05E+00	P2-1	1	-1.53E+00	-1.54E+00
V3	3	1.01E+00	1.01E+00	P5-1	2	-7.27E-01	-7.40E-01
V4	4	1.02E+00	1.02E+00	P3-2	3	-7.09E-01	-7.20E-01
V5	5	1.02E+00	1.02E+00	P4-2	4	-5.45E-01	-5.34E-01
V6	6	1.07E+00	1.08E+00	P5-2	5	-4.06E-01	-3.99E-01
V7	7	1.06E+00	1.07E+00	P4-3	6	2.37E-01	2.37E-01
V8	8	1.09E+00	1.08E+00	P5-4	7	6.17E-01	6.18E-01
V9	9	1.06E+00	1.07E+00	P7-4	8	-2.81E-01	-2.78E-01
V10	10	1.05E+00	1.06E+00	P9-4	9	-1.61E-01	-1.60E-01
V11	11	1.06E+00	1.06E+00	P6-5	10	-4.41E-01	-4.36E-01
V12	12	1.06E+00	1.06E+00	P11-6	11	-7.30E-02	-7.34E-02
V13	13	1.05E+00	1.06E+00	P12-6	12	-7.71E-02	-7.72E-02
V14	14	1.04E+00	1.04E+00	P13-6	13	-1.75E-01	-1.79E-01
P1	1	2.32E+00	2.34E+00	P8-7	14	0.00E+00	0.00E+00
P2	2	1.83E-01	1.86E-01	P9-7	15	-2.81E-01	-2.86E-01
P3	3	-9.42E-01	-9.61E-01	P10-9	16	-5.21E-02	-5.18E-02
P4	4	-4.78E-01	-4.72E-01	P14-9	17	-9.31E-02	-9.18E-02
P5	5	-7.60E-02	-7.49E-02	P11-10	18	3.80E-02	3.86E-02
P6	6	-1.12E-01	-1.13E-01	P13-12	19	-1.61E-02	-1.59E-02
P7	7	0.00E+00	0.00E+00	P14-13	20	-5.59E-02	-5.64E-02
P8	8	0.00E+00	0.00E+00	Q1-2	1	-2.04E-01	-2.06E-01
P9	9	-2.95E-01	-2.98E-01	Q1-5	2	3.86E-02	3.81E-02
P10	10	-9.00E-02	-8.92E-02	Q2-3	3	3.56E-02	3.49E-02
P11	11	-3.50E-02	-3.49E-02	Q2-4	4	-1.55E-02	-1.59E-02
P12	12	-6.10E-02	-6.01E-02	Q2-5	5	1.17E-02	1.21E-02
P13	13	-1.35E-01	-1.32E-01	Q3-4	6	4.47E-02	4.56E-02
P14	14	-1.49E-01	-1.51E-01	Q4-5	7	1.58E-01	1.53E-01
Q1	1	-1.65E-01	-1.65E-01	Q4-7	8	-9.68E-02	-9.78E-02
Q2	2	3.09E-01	3.07E-01	Q4-9	9	-4.28E-03	-4.28E-03
Q3	3	6.08E-02	6.00E-02	Q5-6	10	1.25E-01	1.25E-01
Q4	4	3.90E-02	3.87E-02	Q6-11	11	3.56E-02	3.53E-02
Q5	5	-1.60E-02	-1.55E-02	Q6-12	12	2.50E-02	2.45E-02
Q6	6	5.23E-02	5.37E-02	Q6-13	13	7.22E-02	7.28E-02
Q7	7	0.00E+00	0.00E+00	Q7-8	14	-1.72E-01	-1.66E-01
Q8	8	1.76E-01	1.81E-01	Q7-9	15	5.78E-02	5.64E-02
Q9	9	-1.66E-01	-1.61E-01	Q9-10	16	4.22E-02	4.37E-02

Q10	10	-5.80E-02	-5.83E-02	Q9-14	17	3.61E-02	3.72E-02
Q11	11	-1.80E-02	-1.77E-02	Q10-11	18	-1.62E-02	-1.57E-02
Q12	12	-1.60E-02	-1.59E-02	Q12-13	19	7.54E-03	7.54E-03
Q13	13	-5.80E-02	-5.75E-02	Q13-14	20	1.75E-02	1.81E-02
Q14	14	-5.00E-02	-5.05E-02	Q2-1	1	2.77E-01	2.82E-01
P1-2	1	1.57E+00	1.54E+00	Q5-1	2	2.23E-02	2.28E-02
P1-5	2	7.55E-01	7.57E-01	Q3-2	3	1.60E-02	1.60E-02
P2-3	3	7.32E-01	7.20E-01	Q4-2	4	3.02E-02	3.09E-02
P2-4	4	5.61E-01	5.56E-01	Q5-2	5	-2.10E-02	-2.18E-02
P2-5	5	4.15E-01	4.20E-01	Q4-3	6	-4.84E-02	-5.02E-02
P3-4	6	-2.33E-01	-2.34E-01	Q5-4	7	-1.42E-01	-1.44E-01
P4-5	7	-6.12E-01	-6.07E-01	Q7-4	8	1.14E-01	1.10E-01
P4-7	8	2.81E-01	2.81E-01	Q9-4	9	1.73E-02	1.74E-02
P4-9	9	1.61E-01	1.61E-01	Q6-5	10	-8.05E-02	-7.80E-02
P5-6	10	4.41E-01	4.33E-01	Q11-6	11	-3.44E-02	-3.42E-02
P6-11	11	7.35E-02	7.21E-02	Q12-6	12	-2.35E-02	-2.28E-02
P6-12	12	7.79E-02	7.78E-02	Q13-6	13	-6.80E-02	-7.02E-02
P6-13	13	1.77E-01	1.78E-01	Q8-7	14	1.76E-01	1.79E-01
P7-8	14	0.00E+00	0.00E+00	Q9-7	15	-4.98E-02	-5.07E-02
P7-9	15	2.81E-01	2.79E-01	Q10-9	16	-4.18E-02	-4.25E-02
P9-10	16	5.23E-02	5.27E-02	Q14-9	17	-3.36E-02	-3.33E-02
P9-14	17	9.43E-02	9.57E-02	Q11-10	18	1.64E-02	1.62E-02
P10-11	18	-3.79E-02	-3.80E-02	Q13-12	19	-7.48E-03	-7.58E-03
P12-13	19	1.61E-02	1.58E-02	Q14-13	20	-1.64E-02	-1.60E-02

A.1.5. SCADA Meter Distribution for 14-bus Test Case

Table 0.4 SCADA Meter Distribution for 14-Bus System Test Case

Voltage Magnitude		Real Power Injections		Reactive Power Injections		Real Power Flows		Reactive Power Flows	
Type	Index	Type	Index	Type	Index	Type	Index	Type	Index
V1	1	P1	1	Q1	1	P1-2	1	Q1-2	1
V3	3	P2	2	Q2	2	P1-5	2	Q1-5	2
V11	11	P3	3	Q3	3	P2-3	3	Q2-3	3
V13	13	P6	6	Q6	6	P3-4	6	Q3-4	6
		P7	7	Q9	9	P4-7	8	Q4-7	8
		P9	9	Q10	10	P6-11	11	Q6-11	11
		P10	10	Q12	12	P6-13	13	Q6-13	13
		P12	12	Q13	13	P7-8	14	Q7-8	14
		P13	13			P9-14	17	Q9-14	17
						P12-13	19	Q12-13	19
						P13-14	20	Q13-14	20
						P2-1	1	Q2-1	1
						P3-2	3	Q3-2	3

						P5-4	7	Q5-4	7
						P8-7	14	Q11-6	11
						P11-6	11	Q8-7	14
						P13-12	19	Q13-12	19

A.2. 30-Bus System Details

A.2.1. Single Line Diagram

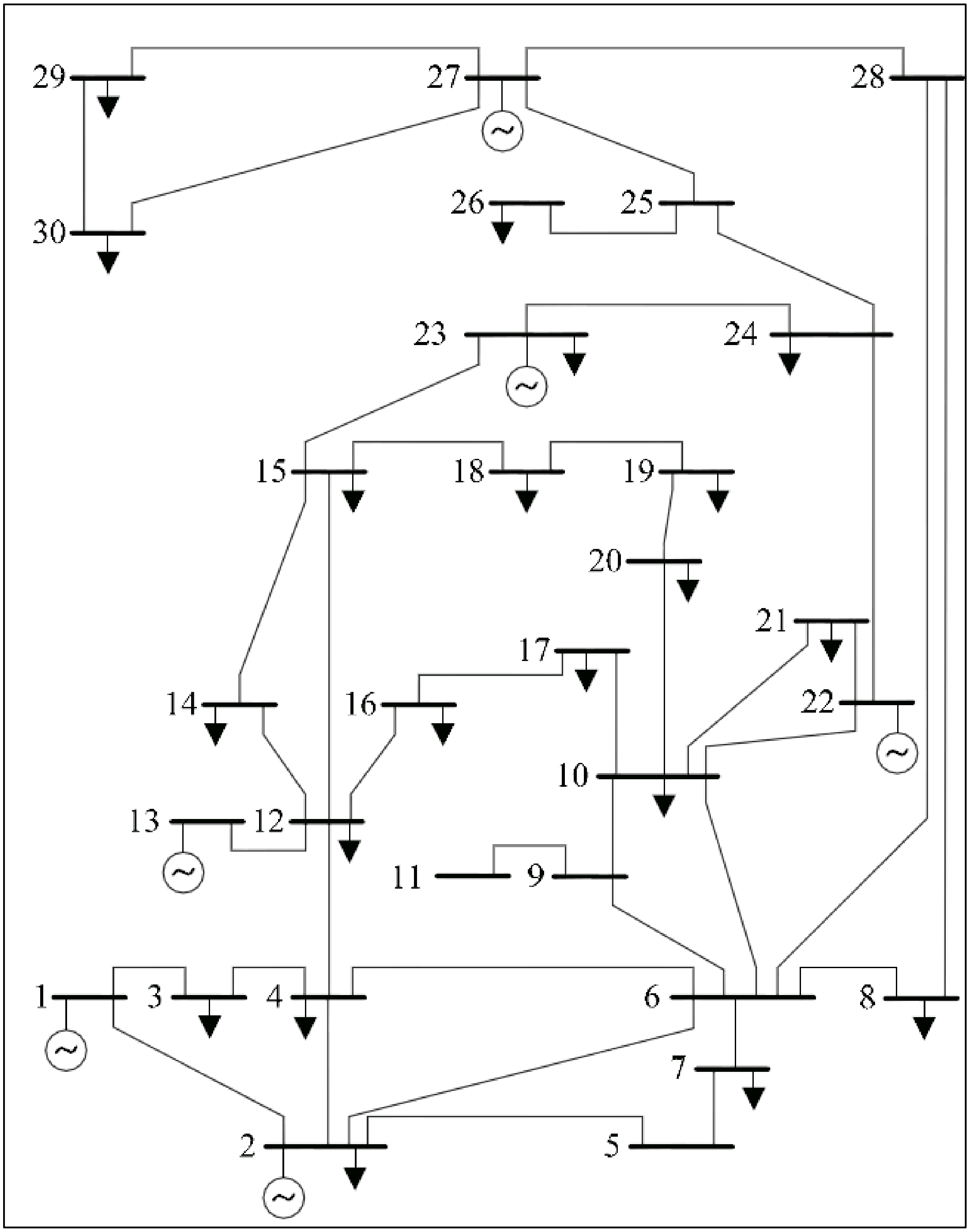

Figure 0.2 Single Line Diagram of IEEE 30-bus power system [98]

A.2.2. Line Data

Table 0.5 Line Data details of IEEE 30-Bus System

From Bus	To Bus	R	X	B	Tap Setting
1	2	0.0192	0.0575	0.0528	0
1	3	0.0452	0.1652	0.0408	0
2	4	0.057	0.1737	0.0368	0
3	4	0.0132	0.0379	0.0084	0
2	5	0.0472	0.1983	0.0418	0
2	6	0.0581	0.1763	0.0374	0
4	6	0.0119	0.0414	0.009	0
5	7	0.046	0.116	0.0204	0
6	7	0.0267	0.082	0.017	0
6	8	0.012	0.042	0.009	0
6	9	0	0.208	0	0.978
6	10	0	0.556	0	0.969
9	11	0	0.208	0	0
9	10	0	0.11	0	0
4	12	0	0.256	0	0.932
12	13	0	0.14	0	0
12	14	0.1231	0.2559	0	0
12	15	0.0662	0.1304	0	0
12	16	0.0945	0.1987	0	0
14	15	0.221	0.1997	0	0
16	17	0.0524	0.1923	0	0
15	18	0.1073	0.2185	0	0
18	19	0.0639	0.1292	0	0
19	20	0.034	0.068	0	0
10	20	0.0936	0.209	0	0
10	17	0.0324	0.0845	0	0
10	21	0.0348	0.0749	0	0
10	22	0.0727	0.1499	0	0
21	22	0.0116	0.0236	0	0
15	23	0.1	0.202	0	0
22	24	0.115	0.179	0	0
23	24	0.132	0.27	0	0
24	25	0.1885	0.3292	0	0
25	26	0.2544	0.38	0	0
25	27	0.1093	0.2087	0	0
28	27	0	0.396	0	0.968
27	29	0.2198	0.4153	0	0
27	30	0.3202	0.6027	0	0
29	30	0.2399	0.4533	0	0
8	28	0.0636	0.2	0.0428	0
6	28	0.0169	0.0599	0.013	0

A.2.3. Bus Data

Table 0.6 Bus Data details of IEEE 30-Bus System

Sr	Bus Type	|V|	Generation		Load		Generation Limits	
			MW	MVAR	MW	MVAR	Max	Min
1	3	1.06	260.95	-20.41	0	0	10	0
2	2	1.043	40	56.06	21.7	12.7	50	-40
3	1	1.021	0	0	2.4	1.2	-	-
4	1	1.012	0	0	7.6	1.6	-	-
5	2	1.01	0	35.65	94.2	19	40	-40
6	1	1.01	0	0	0	0	-	-
7	1	1.002	0	0	22.8	10.9	-	-
8	2	1.01	0	36.11	30	30	40	-10
9	1	1.051	0	0	0	0	-	-
10	1	1.045	0	0	5.8	2	-	-
11	2	1.082	0	16.05	0	0	24	-6
12	1	1.057	0	0	11.2	7.5	-	-
13	2	1.071	0	10.45	0	0	0	10.45
14	1	1.042	0	0	6.2	1.6	-	-
15	1	1.038	0	0	8.2	2.5	-	-
16	1	1.045	0	0	3.5	1.8	-	-
17	1	1.04	0	0	9	5.8	-	-
18	1	1.028	0	0	3.2	0.9	-	-
19	1	1.026	0	0	9.5	3.4	-	-
20	1	1.03	0	0	2.2	0.7	-	-
21	1	1.033	0	0	17.5	11.2	-	-
22	1	1.033	0	0	0	0	-	-
23	1	1.027	0	0	3.2	1.6	-	-
24	1	1.021	0	0	8.7	6.7	-	-
25	1	1.017	0	0	0	0	-	-
26	1	1	0	0	3.5	2.3	-	-
27	1	1.023	0	0	0	0	-	-
28	1	1.007	0	0	0	0	-	-
29	1	1.003	0	0	2.4	0.9	-	-
30	1	0.992	0	0	10.6	1.9	-	-

A.2.4. Load Flow Solutions and Corresponding Measurement Values

Table 0.7 Load Flow and Simulated Measurement values for 30-bus System

Type	Index	Actual	Measurement	Type	Index	Actual	Measurement
Vm-1	1	1.06E+00	1.05E+00	P 27-30	38	7.09E-02	7.22E-02
Vm-2	2	1.05E+00	1.04E+00	P 29-30	39	3.70E-02	3.71E-02
Vm-3	3	1.02E+00	1.02E+00	P 8-28	40	-5.45E-03	-5.40E-03

Vm-4	4	1.01E+00	1.01E+00	P 6-28	41	1.87E-01	1.86E-01
Vm-5	5	1.01E+00	1.02E+00	P 2-1	1	-1.68E+00	-1.65E+00
Vm-6	6	1.01E+00	1.01E+00	P 3-1	2	-8.45E-01	-8.42E-01
Vm-7	7	1.00E+00	1.00E+00	P 4-2	3	-4.26E-01	-4.18E-01
Vm-8	8	1.01E+00	1.00E+00	P 4-3	4	-8.13E-01	-8.01E-01
Vm-9	9	1.05E+00	1.05E+00	P 5-2	5	-7.94E-01	-8.03E-01
Vm-10	10	1.05E+00	1.05E+00	P 6-2	6	-5.84E-01	-5.80E-01
Vm-11	11	1.08E+00	1.08E+00	P 6-4	7	-7.15E-01	-7.03E-01
Vm-12	12	1.06E+00	1.06E+00	P 7-5	8	1.50E-01	1.50E-01
Vm-13	13	1.07E+00	1.07E+00	P 7-6	9	-3.78E-01	-3.73E-01
Vm-14	14	1.04E+00	1.04E+00	P 8-6	10	-2.95E-01	-2.99E-01
Vm-15	15	1.04E+00	1.03E+00	P 9-6	11	-2.77E-01	-2.76E-01
Vm-16	16	1.04E+00	1.03E+00	P 10-6	12	-1.58E-01	-1.59E-01
Vm-17	17	1.04E+00	1.04E+00	P 11-9	13	0.00E+00	0.00E+00
Vm-18	18	1.03E+00	1.03E+00	P 10-9	14	-2.77E-01	-2.80E-01
Vm-19	19	1.03E+00	1.03E+00	P 12-4	15	-4.42E-01	-4.50E-01
Vm-20	20	1.03E+00	1.03E+00	P 13-12	16	0.00E+00	0.00E+00
Vm-21	21	1.03E+00	1.04E+00	P 14-12	17	-7.78E-02	-7.82E-02
Vm-22	22	1.03E+00	1.04E+00	P 15-12	18	-1.77E-01	-1.73E-01
Vm-23	23	1.03E+00	1.03E+00	P 16-12	19	-7.19E-02	-7.12E-02
Vm-24	24	1.02E+00	1.03E+00	P 15-14	20	-1.58E-02	-1.58E-02
Vm-25	25	1.02E+00	1.01E+00	P 17-16	21	-3.68E-02	-3.71E-02
Vm-26	26	1.00E+00	1.00E+00	P 18-15	22	-5.98E-02	-6.00E-02
Vm-27	27	1.02E+00	1.03E+00	P 19-18	23	-2.77E-02	-2.73E-02
Vm-28	28	1.01E+00	1.01E+00	P 20-19	24	6.74E-02	6.87E-02
Vm-29	29	1.00E+00	1.00E+00	P 20-10	25	-8.94E-02	-9.02E-02
Vm-30	30	9.92E-01	9.86E-01	P 17-10	26	-5.32E-02	-5.37E-02
P-1	1	2.61E+00	2.61E+00	P 21-10	27	-1.57E-01	-1.56E-01
P-2	2	1.83E-01	1.82E-01	P 22-10	28	-7.57E-02	-7.64E-02
P-3	3	-2.40E-02	-2.43E-02	P 22-21	29	1.83E-02	1.84E-02
P-4	4	-7.60E-02	-7.51E-02	P 23-15	30	-5.00E-02	-5.07E-02
P-5	5	-9.42E-01	-9.37E-01	P 24-22	31	-5.69E-02	-5.68E-02
P-6	6	0.00E+00	0.00E+00	P 24-23	32	-1.80E-02	-1.77E-02
P-7	7	-2.28E-01	-2.31E-01	P 25-24	33	1.22E-02	1.24E-02
P-8	8	-3.00E-01	-2.99E-01	P 26-25	34	-3.50E-02	-3.57E-02
P-9	9	0.00E+00	0.00E+00	P 27-25	35	4.79E-02	4.88E-02
P-10	10	-5.80E-02	-5.71E-02	P 27-28	36	-1.81E-01	-1.84E-01
P-11	11	0.00E+00	0.00E+00	P 29-27	37	-6.10E-02	-6.17E-02
P-12	12	-1.12E-01	-1.12E-01	P 30-27	38	-6.93E-02	-6.91E-02
P-13	13	0.00E+00	0.00E+00	P 30-29	39	-3.67E-02	-3.67E-02
P-14	14	-6.20E-02	-6.13E-02	P 28-8	40	5.47E-03	5.38E-03
P-15	15	-8.20E-02	-8.13E-02	P 28-6	41	-1.86E-01	-1.86E-01
P-16	16	-3.50E-02	-3.49E-02	Q 1-2	1	-2.47E-01	-2.52E-01
P-17	17	-9.00E-02	-9.13E-02	Q 1-3	2	4.28E-02	4.21E-02
P-18	18	-3.20E-02	-3.22E-02	Q 2-4	3	4.75E-02	4.81E-02
P-19	19	-9.50E-02	-9.44E-02	Q 3-4	4	-3.85E-02	-3.94E-02
P-20	20	-2.20E-02	-2.24E-02	Q 2-5	5	2.78E-02	2.68E-02

P-21	21	-1.75E-01	-1.78E-01	Q 2-6	6	1.37E-02	1.35E-02
P-22	22	0.00E+00	0.00E+00	Q 4-6	7	-1.59E-01	-1.58E-01
P-23	23	-3.20E-02	-3.16E-02	Q 5-7	8	1.15E-01	1.15E-01
P-24	24	-8.70E-02	-8.56E-02	Q 6-7	9	-2.78E-02	-2.84E-02
P-25	25	0.00E+00	0.00E+00	Q 6-8	10	-7.20E-02	-7.36E-02
P-26	26	-3.50E-02	-3.45E-02	Q 6-9	11	-8.09E-02	-8.22E-02
P-27	27	0.00E+00	0.00E+00	Q 6-10	12	1.87E-03	1.83E-03
P-28	28	0.00E+00	0.00E+00	Q 9-11	13	-1.56E-01	-1.52E-01
P-29	29	-2.40E-02	-2.36E-02	Q 9-10	14	5.88E-02	5.80E-02
P-30	30	-1.06E-01	-1.06E-01	Q 4-12	15	1.44E-01	1.49E-01
Q-1	1	-2.04E-01	-2.06E-01	Q 12-13	16	-1.03E-01	-1.02E-01
Q-2	2	4.34E-01	4.43E-01	Q 12-14	17	2.40E-02	2.37E-02
Q-3	3	-1.20E-02	-1.15E-02	Q 12-15	18	6.79E-02	6.99E-02
Q-4	4	-1.60E-02	-1.54E-02	Q 12-16	19	3.35E-02	3.35E-02
Q-5	5	1.67E-01	1.66E-01	Q 14-15	20	6.46E-03	6.34E-03
Q-6	6	0.00E+00	0.00E+00	Q 16-17	21	1.44E-02	1.39E-02
Q-7	7	-1.09E-01	-1.11E-01	Q 15-18	22	1.60E-02	1.53E-02
Q-8	8	6.11E-02	6.10E-02	Q 18-19	23	6.17E-03	5.93E-03
Q-9	9	0.00E+00	0.00E+00	Q 19-20	24	-2.79E-02	-2.90E-02
Q-10	10	-2.00E-02	-2.07E-02	Q 10-20	25	3.71E-02	3.62E-02
Q-11	11	1.61E-01	1.55E-01	Q 10-17	26	4.43E-02	4.49E-02
Q-12	12	-7.50E-02	-7.27E-02	Q 10-21	27	1.00E-01	9.70E-02
Q-13	13	1.05E-01	1.07E-01	Q 10-22	28	4.60E-02	4.70E-02
Q-14	14	-1.60E-02	-1.63E-02	Q 21-22	29	-1.43E-02	-1.43E-02
Q-15	15	-2.50E-02	-2.55E-02	Q 15-23	30	2.91E-02	2.98E-02
Q-16	16	-1.80E-02	-1.80E-02	Q 22-24	31	3.06E-02	2.95E-02
Q-17	17	-5.80E-02	-5.99E-02	Q 23-24	32	1.24E-02	1.25E-02
Q-18	18	-9.00E-03	-8.73E-03	Q 24-25	33	2.01E-02	1.96E-02
Q-19	19	-3.40E-02	-3.48E-02	Q 25-26	34	2.37E-02	2.33E-02
Q-20	20	-7.00E-03	-7.04E-03	Q 25-27	35	-3.71E-03	-3.82E-03
Q-21	21	-1.12E-01	-1.11E-01	Q 28-27	36	5.04E-02	5.19E-02
Q-22	22	0.00E+00	0.00E+00	Q 27-29	37	1.67E-02	1.61E-02
Q-23	23	-1.60E-02	-1.59E-02	Q 27-30	38	1.66E-02	1.73E-02
Q-24	24	-6.70E-02	-6.66E-02	Q 29-30	39	6.06E-03	6.03E-03
Q-25	25	0.00E+00	0.00E+00	Q 8-28	40	-5.45E-03	-5.62E-03
Q-26	26	-2.30E-02	-2.32E-02	Q 6-27	41	1.15E-03	1.14E-03
Q-27	27	0.00E+00	0.00E+00	Q 2-1	1	3.45E-01	3.36E-01
Q-28	28	0.00E+00	0.00E+00	Q 3-1	2	2.65E-02	2.76E-02
Q-29	29	-9.00E-03	-9.03E-03	Q 4-2	3	-5.54E-02	-5.69E-02
Q-30	30	-1.90E-02	-1.90E-02	Q 4-3	4	5.44E-02	5.25E-02
P 1-2	1	1.73E+00	1.74E+00	Q 5-2	5	5.17E-02	5.08E-02
P 1-3	2	8.76E-01	8.71E-01	Q 6-2	6	5.80E-03	6.02E-03
P 2-4	3	4.37E-01	4.39E-01	Q 6-4	7	1.72E-01	1.77E-01
P 3-4	4	8.21E-01	8.35E-01	Q 7-5	8	-1.31E-01	-1.29E-01
P 2-5	5	8.24E-01	8.20E-01	Q 7-6	9	2.23E-02	2.23E-02
P 2-6	6	6.04E-01	5.99E-01	Q 8-6	10	6.66E-02	6.76E-02
P 4-6	7	7.21E-01	7.29E-01	Q 9-6	11	9.72E-02	9.72E-02

P 5-7	8	-1.48E-01	-1.47E-01	Q 10-6	12	1.10E-02	1.06E-02
P 6-7	9	3.81E-01	3.87E-01	Q 11-9	13	1.61E-01	1.63E-01
P 6-8	10	2.96E-01	2.92E-01	Q 10-9	14	-5.08E-02	-5.21E-02
P 6-9	11	2.77E-01	2.72E-01	Q 12-4	15	-9.72E-02	-1.00E-01
P 6-10	12	1.58E-01	1.60E-01	Q 13-12	16	1.05E-01	1.01E-01
P 9-11	13	0.00E+00	0.00E+00	Q 14-12	17	-2.25E-02	-2.23E-02
P 9-10	14	2.77E-01	2.75E-01	Q 15-12	18	-6.36E-02	-6.29E-02
P 4-12	15	4.42E-01	4.49E-01	Q 16-12	19	-3.24E-02	-3.25E-02
P 12-13	16	0.00E+00	0.00E+00	Q 15-14	20	-6.40E-03	-6.51E-03
P 12-14	17	7.86E-02	8.00E-02	Q 17-16	21	-1.41E-02	-1.46E-02
P 12-15	18	1.79E-01	1.80E-01	Q 18-15	22	-1.52E-02	-1.49E-02
P 12-16	19	7.24E-02	7.27E-02	Q 19-18	23	-6.07E-03	-6.21E-03
P 14-15	20	1.58E-02	1.56E-02	Q 20-19	24	2.83E-02	2.82E-02
P 16-17	21	3.69E-02	3.72E-02	Q 20-10	25	-3.53E-02	-3.63E-02
P 15-18	22	6.02E-02	5.93E-02	Q 17-10	26	-4.39E-02	-4.37E-02
P 18-19	23	2.78E-02	2.81E-02	Q 21-10	27	-9.77E-02	-9.57E-02
P 19-20	24	-6.73E-02	-6.75E-02	Q 22-10	28	-4.49E-02	-4.39E-02
P 10-20	25	9.03E-02	8.99E-02	Q 22-21	29	1.43E-02	1.45E-02
P 10-17	26	5.33E-02	5.36E-02	Q 23-15	30	-2.84E-02	-2.85E-02
P 10-21	27	1.58E-01	1.57E-01	Q 24-22	31	-2.99E-02	-3.08E-02
P 10-22	28	7.62E-02	7.51E-02	Q 24-23	32	-1.23E-02	-1.24E-02
P 21-22	29	-1.83E-02	-1.79E-02	Q 25-24	33	-2.00E-02	-1.97E-02
P 15-23	30	5.04E-02	5.11E-02	Q 26-25	34	-2.30E-02	-2.24E-02
P 22-24	31	5.74E-02	5.80E-02	Q 27-25	35	4.17E-03	4.24E-03
P 23-24	32	1.80E-02	1.79E-02	Q 27-28	36	-3.75E-02	-3.79E-02
P 24-25	33	-1.21E-02	-1.18E-02	Q 29-27	37	-1.51E-02	-1.52E-02
P 25-26	34	3.54E-02	3.57E-02	Q 30-27	38	-1.36E-02	-1.32E-02
P 25-27	35	-4.76E-02	-4.80E-02	Q 30-29	39	-5.42E-03	-5.45E-03
P 28-27	36	1.81E-01	1.79E-01	Q 28-8	40	-3.80E-02	-3.95E-02
P 27-29	37	6.19E-02	6.31E-02	Q 28-6	41	-1.23E-02	-1.19E-02

A.2.5. SCADA Meter Distribution for 30-bus Test Case

Table 0.8 SCADA Meter Distribution for 30-Bus System Test Case

Voltage Magnitude		Real Power Injections		Reactive Power Injections		Real Power Flows		Reactive Power Flows	
Type	Index	Type	Index	Type	Index	Type	Index	Type	Index
V1	1	P1	1	Q1	1	P1-3	2	Q1-3	2
V3	3	P2	2	Q2	2	P2-4	3	Q2-4	3
V4	4	P4	4	Q4	4	P2-5	5	Q2-5	5
V5	5	P5	5	Q5	5	P4-6	7	Q4-6	7
V8	8	P7	7	Q7	7	P5-7	8	Q5-7	8
V10	10	P9	9	Q9	9	P6-7	9	Q6-7	9
V12	12	P10	10	Q10	10	P6-8	10	Q6-8	10

V18	18	P14	14	Q14	14	P6-9	11	Q6-9	11
V21	21	P15	15	Q15	15	P6-10	12	9-11	13
V24	24	P16	16	Q16	16	P9-11	13	Q12-13	16
V25	25	P18	18	Q18	18	P12-13	16	Q12-14	17
V26	26	P19	19	Q19	19	P12-14	17	Q12-16	19
V28	28	P21	21	Q21	21	P12-16	19	Q14-15	20
V29	29	P24	24	Q24	24	P14-15	20	Q15-18	22
		P29	29	Q30	30	P15-18	22	Q18-19	23
		P30	30			P18-19	23	Q10-17	26
						P10-17	26	Q22-24	31
						P22-24	31	Q23-24	32
						P23-24	32	Q24-25	33
						P24-25	33	Q25-26	34
						P25-26	34	Q25-27	35
						P25-27	35	Q28-27	36
						P28-27	36	Q27-30	38
						P27-30	38	Q29-30	39
						P29-30	39	Q2-1	1
						P2-1	1	Q4-3	4
						P4-3	4	Q6-2	6
						P6-2	6	Q10-9	14
						P10-9	14	Q2-4	15
						P12-4	15	Q15-12	18
						P15-12	18	Q20-19	24
						P20-19	24	Q20-10	25
						P20-10	25	Q21-10	27
						P21-10	27	Q22-21	29
						P22-21	29	Q23-15	30
						P23-15	30	Q24-22	31
						P24-22	31	Q24-23	32
						P24-23	32	Q27-28	36
						P27-28	36	Q30-29	39
						P30-29	39	Q28-8	40
						P28-8	40		

A.3. 118-Bus System Details

A.3.1. Single Line Diagram

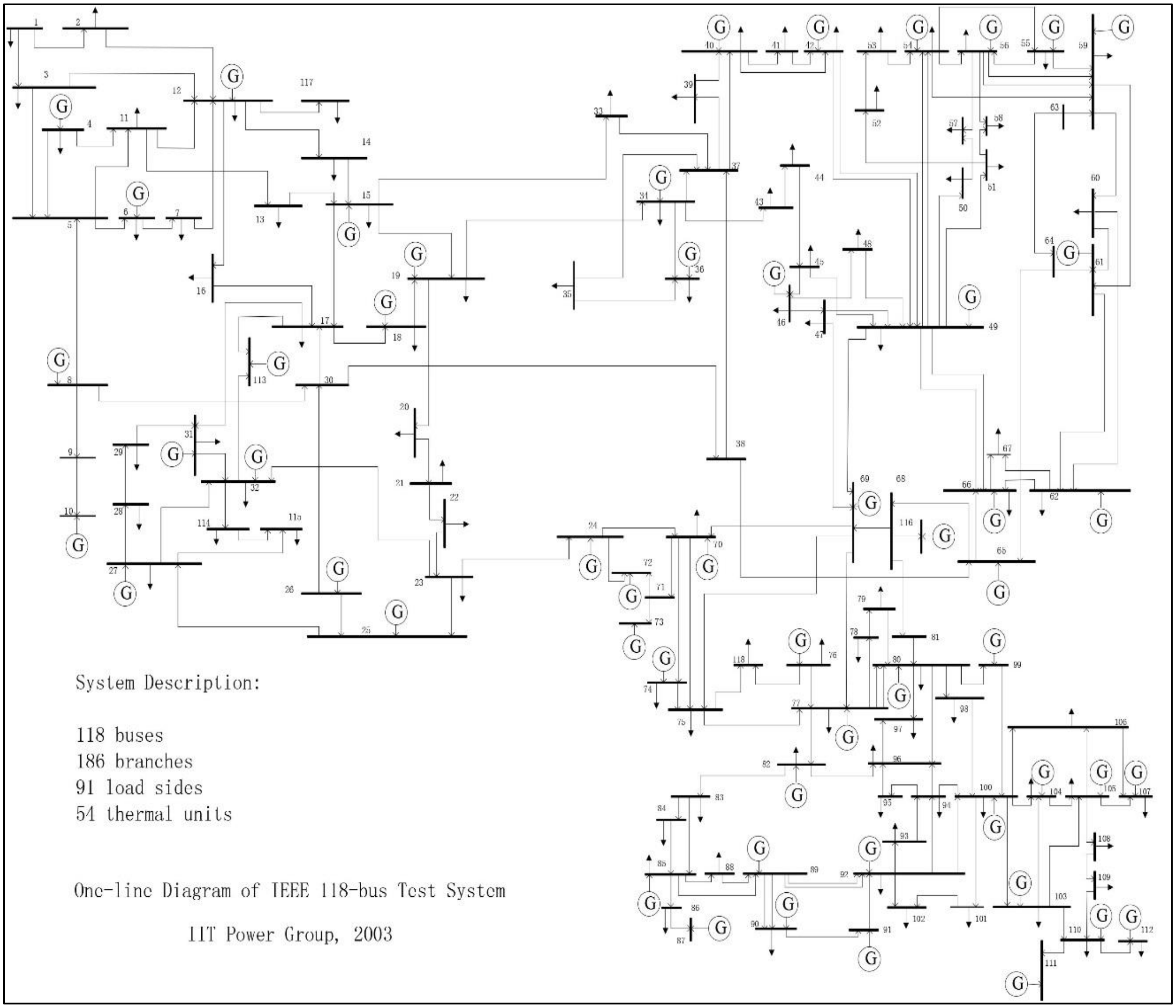

Figure 0.3 Single Line Diagram of IEEE 118-bus power system [99]

A.3.2. Line Data

Table 0.9 Line Data details of IEEE 118-Bus System

From Bus	To Bus	R	X	B	Tap Setting
1	2	0.0303	0.0999	0.0254	0
1	3	0.0129	0.0424	0.01082	0
4	5	0.00176	0.00798	0.0021	0
3	5	0.0241	0.108	0.0284	0
5	6	0.0119	0.054	0.01426	0
6	7	0.00459	0.0208	0.0055	0
8	9	0.00244	0.0305	1.162	0
8	5	0	0.0267	0	0.985
9	10	0.00258	0.0322	1.23	0
4	11	0.0209	0.0688	0.01748	0
5	11	0.0203	0.0682	0.01738	0
11	12	0.00595	0.0196	0.00502	0
2	12	0.0187	0.0616	0.01572	0
3	12	0.0484	0.16	0.0406	0
7	12	0.00862	0.034	0.00874	0
11	13	0.02225	0.0731	0.01876	0
12	14	0.0215	0.0707	0.01816	0
13	15	0.0744	0.2444	0.06268	0
14	15	0.0595	0.195	0.0502	0
12	16	0.0212	0.0834	0.0214	0
15	17	0.0132	0.0437	0.0444	0
16	17	0.0454	0.1801	0.0466	0
17	18	0.0123	0.0505	0.01298	0
18	19	0.01119	0.0493	0.01142	0
19	20	0.0252	0.117	0.0298	0
15	19	0.012	0.0394	0.0101	0
20	21	0.0183	0.0849	0.0216	0
21	22	0.0209	0.097	0.0246	0
22	23	0.0342	0.159	0.0404	0
23	24	0.0135	0.0492	0.0498	0
23	25	0.0156	0.08	0.0864	0
26	25	0	0.0382	0	0.96
25	27	0.0318	0.163	0.1764	0
27	28	0.01913	0.0855	0.0216	0
28	29	0.0237	0.0943	0.0238	0
30	17	0	0.0388	0	0.96
8	30	0.00431	0.0504	0.514	0
26	30	0.00799	0.086	0.908	0
17	31	0.0474	0.1563	0.0399	0
29	31	0.0108	0.0331	0.0083	0
23	32	0.0317	0.1153	0.1173	0

31	32	0.0298	0.0985	0.0251	0
27	32	0.0229	0.0755	0.01926	0
15	33	0.038	0.1244	0.03194	0
19	34	0.0752	0.247	0.0632	0
35	36	0.00224	0.0102	0.00268	0
35	37	0.011	0.0497	0.01318	0
33	37	0.0415	0.142	0.0366	0
34	36	0.00871	0.0268	0.00568	0
34	37	0.00256	0.0094	0.00984	0
38	37	0	0.0375	0	0.935
37	39	0.0321	0.106	0.027	0
37	40	0.0593	0.168	0.042	0
30	38	0.00464	0.054	0.422	0
39	40	0.0184	0.0605	0.01552	0
40	41	0.0145	0.0487	0.01222	0
40	42	0.0555	0.183	0.0466	0
41	42	0.041	0.135	0.0344	0
43	44	0.0608	0.2454	0.06068	0
34	43	0.0413	0.1681	0.04226	0
44	45	0.0224	0.0901	0.0224	0
45	46	0.04	0.1356	0.0332	0
46	47	0.038	0.127	0.0316	0
46	48	0.0601	0.189	0.0472	0
47	49	0.0191	0.0625	0.01604	0
42	49	0.0715	0.323	0.086	0
42	49	0.0715	0.323	0.086	0
45	49	0.0684	0.186	0.0444	0
48	49	0.0179	0.0505	0.01258	0
49	50	0.0267	0.0752	0.01874	0
49	51	0.0486	0.137	0.0342	0
51	52	0.0203	0.0588	0.01396	0
52	53	0.0405	0.1635	0.04058	0
53	54	0.0263	0.122	0.031	0
49	54	0.073	0.289	0.0738	0
49	54	0.0869	0.291	0.073	0
54	55	0.0169	0.0707	0.0202	0
54	56	0.00275	0.00955	0.00732	0
55	56	0.00488	0.0151	0.00374	0
56	57	0.0343	0.0966	0.0242	0
50	57	0.0474	0.134	0.0332	0
56	58	0.0343	0.0966	0.0242	0
51	58	0.0255	0.0719	0.01788	0
54	59	0.0503	0.2293	0.0598	0
56	59	0.0825	0.251	0.0569	0
56	59	0.0803	0.239	0.0536	0
55	59	0.04739	0.2158	0.05646	0
59	60	0.0317	0.145	0.0376	0

59	61	0.0328	0.15	0.0388	0
60	61	0.00264	0.0135	0.01456	0
60	62	0.0123	0.0561	0.01468	0
61	62	0.00824	0.0376	0.0098	0
63	59	0	0.0386	0	0.96
63	64	0.00172	0.02	0.216	0
64	61	0	0.0268	0	0.985
38	65	0.00901	0.0986	1.046	0
64	65	0.00269	0.0302	0.38	0
49	66	0.018	0.0919	0.0248	0
49	66	0.018	0.0919	0.0248	0
62	66	0.0482	0.218	0.0578	0
62	67	0.0258	0.117	0.031	0
65	66	0	0.037	0	0.935
66	67	0.0224	0.1015	0.02682	0
65	68	0.00138	0.016	0.638	0
47	69	0.0844	0.2778	0.07092	0
49	69	0.0985	0.324	0.0828	0
68	69	0	0.037	0	0.935
69	70	0.03	0.127	0.122	0
24	70	0.00221	0.4115	0.10198	0
70	71	0.00882	0.0355	0.00878	0
24	72	0.0488	0.196	0.0488	0
71	72	0.0446	0.18	0.04444	0
71	73	0.00866	0.0454	0.01178	0
70	74	0.0401	0.1323	0.03368	0
70	75	0.0428	0.141	0.036	0
69	75	0.0405	0.122	0.124	0
74	75	0.0123	0.0406	0.01034	0
76	77	0.0444	0.148	0.0368	0
69	77	0.0309	0.101	0.1038	0
75	77	0.0601	0.1999	0.04978	0
77	78	0.00376	0.0124	0.01264	0
78	79	0.00546	0.0244	0.00648	0
77	80	0.017	0.0485	0.0472	0
77	80	0.0294	0.105	0.0228	0
79	80	0.0156	0.0704	0.0187	0
68	81	0.00175	0.0202	0.808	0
81	80	0	0.037	0	0.935
77	82	0.0298	0.0853	0.08174	0
82	83	0.0112	0.03665	0.03796	0
83	84	0.0625	0.132	0.0258	0
83	85	0.043	0.148	0.0348	0
84	85	0.0302	0.0641	0.01234	0
85	86	0.035	0.123	0.0276	0
86	87	0.02828	0.2074	0.0445	0
85	88	0.02	0.102	0.0276	0

85	89	0.0239	0.173	0.047	0
88	89	0.0139	0.0712	0.01934	0
89	90	0.0518	0.188	0.0528	0
89	90	0.0238	0.0997	0.106	0
90	91	0.0254	0.0836	0.0214	0
89	92	0.0099	0.0505	0.0548	0
89	92	0.0393	0.1581	0.0414	0
91	92	0.0387	0.1272	0.03268	0
92	93	0.0258	0.0848	0.0218	0
92	94	0.0481	0.158	0.0406	0
93	94	0.0223	0.0732	0.01876	0
94	95	0.0132	0.0434	0.0111	0
80	96	0.0356	0.182	0.0494	0
82	96	0.0162	0.053	0.0544	0
94	96	0.0269	0.0869	0.023	0
80	97	0.0183	0.0934	0.0254	0
80	98	0.0238	0.108	0.0286	0
80	99	0.0454	0.206	0.0546	0
92	100	0.0648	0.295	0.0472	0
94	100	0.0178	0.058	0.0604	0
95	96	0.0171	0.0547	0.01474	0
96	97	0.0173	0.0885	0.024	0
98	100	0.0397	0.179	0.0476	0
99	100	0.018	0.0813	0.0216	0
100	101	0.0277	0.1262	0.0328	0
92	102	0.0123	0.0559	0.01464	0
101	102	0.0246	0.112	0.0294	0
100	103	0.016	0.0525	0.0536	0
100	104	0.0451	0.204	0.0541	0
103	104	0.0466	0.1584	0.0407	0
103	105	0.0535	0.1625	0.0408	0
100	106	0.0605	0.229	0.062	0
104	105	0.00994	0.0378	0.00986	0
105	106	0.014	0.0547	0.01434	0
105	107	0.053	0.183	0.0472	0
105	108	0.0261	0.0703	0.01844	0
106	107	0.053	0.183	0.0472	0
108	109	0.0105	0.0288	0.0076	0
103	110	0.03906	0.1813	0.0461	0
109	110	0.0278	0.0762	0.0202	0
110	111	0.022	0.0755	0.02	0
110	112	0.0247	0.064	0.062	0
17	113	0.00913	0.0301	0.00768	0
32	113	0.0615	0.203	0.0518	0
32	114	0.0135	0.0612	0.01628	0
27	115	0.0164	0.0741	0.01972	0
114	115	0.0023	0.0104	0.00276	0

68	116	0.00034	0.00405	0.164	0
12	117	0.0329	0.14	0.0358	0
75	118	0.0145	0.0481	0.01198	0
76	118	0.0164	0.0544	0.01356	0

A.3.3. Bus Data

Table 0.10 Bus Data details of IEEE 118-Bus System

Sr	Bus Type	|V|	Generation		Load		Generation Limits	
			MW	MVAR	MW	MVAR	Max	Min
1	2	0.955	0	0	51	27	15	-5
2	1	0.971	0	0	20	9	-	-
3	1	0.968	0	0	39	10	-	-
4	2	0.998	0	0	39	12	300	-300
5	1	1.002	0	0	0	0	-	-
6	2	0.99	0	0	52	22	50	-13
7	1	0.989	0	0	19	2	-	-
8	2	1.015	0	0	28	0	300	-300
9	1	1.043	0	0	0	0	-	-
10	2	1.05	450	0	0	0	200	-147
11	1	0.985	0	0	70	23	-	-
12	2	0.99	85	0	47	10	120	-35
13	1	0.968	0	0	34	16	-	-
14	1	0.984	0	0	14	1	-	-
15	2	0.97	0	0	90	30	30	-10
16	1	0.984	0	0	25	10	-	-
17	1	0.995	0	0	11	3	-	-
18	2	0.973	0	0	60	34	50	-16
19	2	0.963	0	0	45	25	24	-8
20	1	0.958	0	0	18	3	-	-
21	1	0.959	0	0	14	8	-	-
22	1	0.97	0	0	10	5	-	-
23	1	1	0	0	7	3	-	-
24	2	0.992	0	0	13	0	300	-300
25	2	1.05	220	0	0	0	140	-47
26	2	1.015	314	0	0	0	1000	-1000
27	2	0.968	0	0	71	13	300	-300
28	1	0.962	0	0	17	7	-	-
29	1	0.963	0	0	24	4	-	-
30	1	0.968	0	0	0	0	-	-
31	2	0.967	7	0	43	27	300	-300
32	2	0.964	0	0	59	23	42	-14
33	1	0.972	0	0	23	9	-	-
34	2	0.986	0	0	59	26	24	-8
35	1	0.981	0	0	33	9	-	-

36	2	0.98	0	0	31	17	24	-8
37	1	0.992	0	0	0	0	-	-
38	1	0.962	0	0	0	0	-	-
39	1	0.97	0	0	27	11	-	-
40	2	0.97	0	0	66	23	300	-300
41	1	0.967	0	0	37	10	-	-
42	2	0.985	0	0	96	23	300	-300
43	1	0.978	0	0	18	7	-	-
44	1	0.985	0	0	16	8	-	-
45	1	0.987	0	0	53	22	-	-
46	2	1.005	19	0	28	10	100	-100
47	1	1.017	0	0	34	0	-	-
48	1	1.021	0	0	20	11	-	-
49	2	1.025	204	0	87	30	210	-85
50	1	1.001	0	0	17	4	-	-
51	1	0.967	0	0	17	8	-	-
52	1	0.957	0	0	18	5	-	-
53	1	0.946	0	0	23	11	-	-
54	2	0.955	48	0	113	32	300	-300
55	2	0.952	0	0	63	22	23	-8
56	2	0.954	0	0	84	18	15	-8
57	1	0.971	0	0	12	3	-	-
58	1	0.959	0	0	12	3	-	-
59	2	0.985	155	0	277	113	180	-60
60	1	0.993	0	0	78	3	-	-
61	2	0.995	160	0	0	0	300	-100
62	2	0.998	0	0	77	14	20	-20
63	1	0.969	0	0	0	0	-	-
64	1	0.984	0	0	0	0	-	-
65	2	1.005	391	0	0	0	200	-67
66	2	1.05	392	0	39	18	200	-67
67	1	1.02	0	0	28	7	-	-
68	1	1.003	0	0	0	0	-	-
69	3	1.035	516.4	0	0	0	300	-300
70	2	0.984	0	0	66	20	32	-10
71	1	0.987	0	0	0	0	-	-
72	2	0.98	0	0	12	0	100	-100
73	2	0.991	0	0	6	0	100	-100
74	2	0.958	0	0	68	27	9	-6
75	1	0.967	0	0	47	11	-	-
76	2	0.943	0	0	68	36	-	-
77	2	1.006	0	0	61	28	23	-8
78	1	1.003	0	0	71	26	70	-20
79	1	1.009	0	0	39	32	-	-
80	2	1.04	477	0	130	26	280	-165
81	1	0.997	0	0	0	0	-	-

82	1	0.989	0	0	54	27	-	-
83	1	0.985	0	0	20	10	-	-
84	1	0.98	0	0	11	7	-	-
85	2	0.985	0	0	24	15	23	-8
86	1	0.987	0	0	21	10	-	-
87	2	1.015	4	0	0	0	1000	-100
88	1	0.987	0	0	48	10	-	-
89	2	1.005	607	0	0	0	300	-210
90	2	0.985	0	0	163	42	300	-300
91	2	0.98	0	0	10	0	100	-100
92	2	0.993	0	0	65	10	9	-3
93	1	0.987	0	0	12	7	-	-
94	1	0.991	0	0	30	16	-	-
95	1	0.981	0	0	42	31	-	-
96	1	0.993	0	0	38	15	-	-
97	1	1.011	0	0	15	9	-	-
98	1	1.024	0	0	34	8	-	-
99	2	1.01	0	0	42	0	100	-100
100	2	1.017	252	0	37	18	155	-50
101	1	0.993	0	0	22	15	-	-
102	1	0.991	0	0	5	3	-	-
103	2	1.001	40	0	23	16	40	-15
104	2	0.971	0	0	38	25	23	-8
105	2	0.965	0	0	31	26	23	-8
106	1	0.962	0	0	43	16	-	-
107	2	0.952	0	0	50	12	200	-200
108	1	0.967	0	0	2	1	-	-
109	1	0.967	0	0	8	3	-	-
110	2	0.973	0	0	39	30	23	-8
111	2	0.98	36	0	0	0	1000	-100
112	2	0.975	0	0	68	13	1000	-100
113	2	0.993	0	0	6	0	200	-100
114	1	0.96	0	0	8	3	-	-
115	1	0.96	0	0	22	7	-	-
116	2	1.005	0	0	184	0	1000	-1000
117	1	0.974	0	0	20	8	-	-
118	1	0.949	0	0	33	15	-	-

A.3.4. Load Flow Solutions and Corresponding Measurement Values

Table 0.11 Load Flow and Simulated Measurement values for 118-bus System

Type	Index	Actual	Measurement	Type	Index	Actual	Measurement
Vm-1	1	9.55E-01	9.60E-01	P 4-11	10	-6.34E-01	-6.26E-01
Vm-2	2	9.71E-01	9.69E-01	P 5-11	11	-7.60E-01	-7.52E-01

Vm-3	3	9.68E-01	9.69E-01	P 11-12	12	-3.41E-01	-3.44E-01
Vm-4	4	9.98E-01	9.89E-01	P 2-12	13	3.27E-01	3.22E-01
Vm-5	5	1.00E+00	9.94E-01	P 3-12	14	9.89E-02	9.71E-02
Vm-6	6	9.90E-01	9.91E-01	P 7-12	15	-1.65E-01	-1.67E-01
Vm-7	7	9.89E-01	9.83E-01	P 11-13	16	-3.48E-01	-3.45E-01
Vm-8	8	1.02E+00	1.02E+00	P 12-14	17	-1.82E-01	-1.80E-01
Vm-9	9	1.04E+00	1.05E+00	P 13-15	18	-7.67E-03	-7.75E-03
Vm-10	10	1.05E+00	1.05E+00	P 14-15	19	-4.21E-02	-4.15E-02
Vm-11	11	9.85E-01	9.83E-01	P 12-16	20	-7.49E-02	-7.35E-02
Vm-12	12	9.90E-01	9.83E-01	P 15-17	21	1.05E+00	1.07E+00
Vm-13	13	9.68E-01	9.66E-01	P 16-17	22	1.77E-01	1.73E-01
Vm-14	14	9.84E-01	9.89E-01	P 17-18	23	-7.94E-01	-7.95E-01
Vm-15	15	9.70E-01	9.70E-01	P 18-19	24	-1.93E-01	-1.96E-01
Vm-16	16	9.84E-01	9.76E-01	P 19-20	25	1.07E-01	1.08E-01
Vm-17	17	9.95E-01	1.00E+00	P 15-19	26	-1.15E-01	-1.13E-01
Vm-18	18	9.73E-01	9.77E-01	P 20-21	27	2.88E-01	2.92E-01
Vm-19	19	9.62E-01	9.71E-01	P 21-22	28	4.33E-01	4.25E-01
Vm-20	20	9.57E-01	9.60E-01	P 22-23	29	5.43E-01	5.34E-01
Vm-21	21	9.58E-01	9.60E-01	P 23-24	30	-8.25E-02	-8.32E-02
Vm-22	22	9.69E-01	9.68E-01	P 23-25	31	1.67E+00	1.70E+00
Vm-23	23	9.99E-01	1.00E+00	P 26-25	32	-9.03E-01	-9.03E-01
Vm-24	24	9.92E-01	9.87E-01	P 25-27	33	-1.37E+0	-1.39E+00
Vm-25	25	1.05E+00	1.05E+00	P 27-28	34	-3.27E-01	-3.30E-01
Vm-26	26	1.02E+00	1.02E+00	P 28-29	35	-1.56E-01	-1.56E-01
Vm-27	27	9.68E-01	9.73E-01	P 30-17	36	-2.31E+0	-2.34E+00
Vm-28	28	9.62E-01	9.60E-01	P 8-30	37	-7.38E-01	-7.44E-01
Vm-29	29	9.63E-01	9.70E-01	P 26-30	38	-2.20E+0	-2.19E+00
Vm-30	30	9.85E-01	9.89E-01	P 17-31	39	-1.46E-01	-1.47E-01
Vm-31	31	9.67E-01	9.65E-01	P 29-31	40	8.43E-02	8.48E-02
Vm-32	32	9.63E-01	9.71E-01	P 23-32	41	-9.02E-01	-9.15E-01
Vm-33	33	9.71E-01	9.61E-01	P 31-32	42	3.02E-01	3.01E-01
Vm-34	34	9.84E-01	9.92E-01	P 27-32	43	-1.25E-01	-1.23E-01
Vm-35	35	9.80E-01	9.82E-01	P 15-33	44	-7.28E-02	-7.18E-02
Vm-36	36	9.80E-01	9.87E-01	P 19-34	45	3.65E-02	3.60E-02
Vm-37	37	9.91E-01	9.97E-01	P 35-36	46	-8.38E-03	-8.35E-03
Vm-38	38	9.61E-01	9.57E-01	P 35-37	47	3.40E-01	3.41E-01
Vm-39	39	9.70E-01	9.74E-01	P 33-37	48	1.59E-01	1.58E-01
Vm-40	40	9.70E-01	9.75E-01	P 34-36	49	-3.02E-01	-3.06E-01
Vm-41	41	9.67E-01	9.64E-01	P 34-37	50	9.46E-01	9.49E-01
Vm-42	42	9.85E-01	9.80E-01	P 38-37	51	-2.43E+0	-2.45E+00
Vm-43	43	9.77E-01	9.78E-01	P 37-39	52	-5.39E-01	-5.48E-01
Vm-44	44	9.84E-01	9.75E-01	P 37-40	53	-4.28E-01	-4.27E-01
Vm-45	45	9.86E-01	9.90E-01	P 30-38	54	-6.21E-01	-6.12E-01
Vm-46	46	1.01E+00	1.01E+00	P 39-40	55	-2.68E-01	-2.65E-01
Vm-47	47	1.02E+00	1.02E+00	P 40-41	56	-1.54E-01	-1.54E-01
Vm-48	48	1.02E+00	1.02E+00	P 40-42	57	1.19E-01	1.20E-01
Vm-49	49	1.03E+00	1.03E+00	P 41-42	58	2.18E-01	2.18E-01

Vm-50	50	1.00E+00	1.01E+00	P 43-44	59	1.68E-01	1.69E-01
Vm-51	51	9.67E-01	9.76E-01	P 34-43	60	-1.41E-02	-1.42E-02
Vm-52	52	9.57E-01	9.60E-01	P 44-45	61	3.30E-01	3.36E-01
Vm-53	53	9.46E-01	9.41E-01	P 45-46	62	3.69E-01	3.69E-01
Vm-54	54	9.55E-01	9.51E-01	P 46-47	63	3.15E-01	3.20E-01
Vm-55	55	9.52E-01	9.52E-01	P 46-48	64	1.49E-01	1.47E-01
Vm-56	56	9.54E-01	9.51E-01	P 47-49	65	9.57E-02	9.60E-02
Vm-57	57	9.71E-01	9.65E-01	P 42-49	66	6.80E-01	6.89E-01
Vm-58	58	9.59E-01	9.50E-01	P 42-49	67	6.80E-01	6.75E-01
Vm-59	59	9.85E-01	9.91E-01	P 45-49	68	5.14E-01	5.13E-01
Vm-60	60	9.93E-01	9.92E-01	P 48-49	69	3.51E-01	3.51E-01
Vm-61	61	9.95E-01	9.88E-01	P 49-50	70	-5.29E-01	-5.21E-01
Vm-62	62	9.98E-01	9.92E-01	P 49-51	71	-6.43E-01	-6.55E-01
Vm-63	63	9.69E-01	9.65E-01	P 51-52	72	-2.84E-01	-2.87E-01
Vm-64	64	9.84E-01	9.78E-01	P 52-53	73	-1.03E-01	-1.03E-01
Vm-65	65	1.01E+00	1.01E+00	P 53-54	74	1.27E-01	1.25E-01
Vm-66	66	1.05E+00	1.06E+00	P 49-54	75	-3.66E-01	-3.60E-01
Vm-67	67	1.02E+00	1.01E+00	P 49-54	76	-3.64E-01	-3.70E-01
Vm-68	68	1.00E+00	9.98E-01	P 54-55	77	-7.06E-02	-7.02E-02
Vm-69	69	1.04E+00	1.04E+00	P 54-56	78	-1.85E-01	-1.86E-01
Vm-70	70	9.84E-01	9.89E-01	P 55-56	79	2.14E-01	2.18E-01
Vm-71	71	9.87E-01	9.89E-01	P 56-57	80	2.32E-01	2.34E-01
Vm-72	72	9.80E-01	9.70E-01	P 50-57	81	-3.52E-01	-3.46E-01
Vm-73	73	9.91E-01	9.97E-01	P 56-58	82	6.69E-02	6.61E-02
Vm-74	74	9.58E-01	9.62E-01	P 51-58	83	-1.87E-01	-1.88E-01
Vm-75	75	9.67E-01	9.58E-01	P 54-59	84	3.09E-01	3.03E-01
Vm-76	76	9.43E-01	9.42E-01	P 56-59	85	2.87E-01	2.83E-01
Vm-77	77	1.01E+00	1.01E+00	P 56-59	86	3.01E-01	3.04E-01
Vm-78	78	1.00E+00	9.94E-01	P 55-59	87	3.52E-01	3.46E-01
Vm-79	79	1.01E+00	1.01E+00	P 59-60	88	4.39E-01	4.43E-01
Vm-80	80	1.04E+00	1.05E+00	P 59-61	89	5.26E-01	5.18E-01
Vm-81	81	9.97E-01	1.01E+00	P 60-61	90	1.12E+00	1.10E+00
Vm-82	82	9.89E-01	9.90E-01	P 60-62	91	9.89E-02	9.74E-02
Vm-83	83	9.84E-01	9.76E-01	P 61-62	92	-2.54E-01	-2.58E-01
Vm-84	84	9.80E-01	9.77E-01	P 63-59	93	-1.52E+0	-1.50E+00
Vm-85	85	9.85E-01	9.76E-01	P 63-64	94	1.52E+00	1.54E+00
Vm-86	86	9.87E-01	9.87E-01	P 64-61	95	-3.05E-01	-3.07E-01
Vm-87	87	1.02E+00	1.01E+00	P 38-65	96	1.84E+00	1.87E+00
Vm-88	88	9.87E-01	9.78E-01	P 64-65	97	1.84E+00	1.83E+00
Vm-89	89	1.01E+00	1.01E+00	P 49-66	98	1.35E+00	1.35E+00
Vm-90	90	9.85E-01	9.89E-01	P 49-66	99	1.35E+00	1.36E+00
Vm-91	91	9.80E-01	9.87E-01	P 62-66	100	3.79E-01	3.83E-01
Vm-92	92	9.90E-01	9.81E-01	P 62-67	101	2.45E-01	2.41E-01
Vm-93	93	9.85E-01	9.93E-01	P 65-66	102	-8.54E-02	-8.71E-02
Vm-94	94	9.90E-01	9.92E-01	P 66-67	103	-5.25E-01	-5.21E-01
Vm-95	95	9.80E-01	9.81E-01	P 65-68	104	-1.42E-01	-1.39E-01
Vm-96	96	9.92E-01	1.00E+00	P 47-69	105	5.87E-01	5.91E-01

Vm-97	97	1.01E+00	1.01E+00	P 49-69	106	4.88E-01	4.91E-01
Vm-98	98	1.02E+00	1.02E+00	P 68-69	107	1.26E+00	1.24E+00
Vm-99	99	1.01E+00	1.01E+00	P 69-70	108	-1.05E+0	-1.03E+00
Vm-100	100	1.02E+00	1.02E+00	P 24-70	109	6.22E-02	6.17E-02
Vm-101	101	9.91E-01	9.86E-01	P 70-71	110	-1.66E-01	-1.64E-01
Vm-102	102	9.89E-01	9.92E-01	P 24-72	111	-1.45E-02	-1.48E-02
Vm-103	103	1.01E+00	1.01E+00	P 71-72	112	-1.06E-01	-1.04E-01
Vm-104	104	9.71E-01	9.76E-01	P 71-73	113	-6.00E-02	-6.08E-02
Vm-105	105	9.65E-01	9.74E-01	P 70-74	114	-1.60E-01	-1.60E-01
Vm-106	106	9.61E-01	9.58E-01	P 70-75	115	1.94E-03	1.90E-03
Vm-107	107	9.52E-01	9.53E-01	P 69-75	116	-1.05E+0	-1.07E+00
Vm-108	108	9.66E-01	9.61E-01	P 74-75	117	5.24E-01	5.25E-01
Vm-109	109	9.67E-01	9.72E-01	P 76-77	118	6.32E-01	6.21E-01
Vm-110	110	9.73E-01	9.83E-01	P 69-77	119	-6.10E-01	-6.04E-01
Vm-111	111	9.80E-01	9.78E-01	P 75-77	120	3.54E-01	3.48E-01
Vm-112	112	9.75E-01	9.67E-01	P 77-78	121	-4.53E-01	-4.53E-01
Vm-113	113	9.93E-01	9.86E-01	P 78-79	122	2.57E-01	2.58E-01
Vm-114	114	9.60E-01	9.65E-01	P 77-80	123	9.83E-01	9.66E-01
Vm-115	115	9.60E-01	9.64E-01	P 77-80	124	4.50E-01	4.48E-01
Vm-116	116	1.01E+00	9.99E-01	P 79-80	125	6.55E-01	6.67E-01
Vm-117	117	9.74E-01	9.70E-01	P 68-81	126	4.42E-01	4.34E-01
Vm-118	118	9.49E-01	9.52E-01	P 81-80	127	4.42E-01	4.49E-01
P-1	1	-5.10E-01	-5.08E-01	P 77-82	128	3.17E-02	3.14E-02
P-2	2	-2.00E-01	-2.02E-01	P 82-83	129	4.76E-01	4.83E-01
P-3	3	-3.90E-01	-3.85E-01	P 83-84	130	2.53E-01	2.56E-01
P-4	4	-3.90E-01	-3.96E-01	P 83-85	131	4.37E-01	4.38E-01
P-5	5	0.00E+00	0.00E+00	P 84-85	132	3.68E-01	3.75E-01
P-6	6	-5.20E-01	-5.19E-01	P 85-86	133	-1.71E-01	-1.73E-01
P-7	7	-1.90E-01	-1.94E-01	P 86-87	134	4.00E-02	3.98E-02
P-8	8	-2.80E-01	-2.82E-01	P 85-88	135	5.09E-01	5.09E-01
P-9	9	0.00E+00	0.00E+00	P 85-89	136	7.25E-01	7.30E-01
P-10	10	4.50E+00	4.47E+00	P 88-89	137	1.00E+00	1.01E+00
P-11	11	-7.00E-01	-6.94E-01	P 89-90	138	-5.65E-01	-5.64E-01
P-12	12	3.80E-01	3.85E-01	P 89-90	139	-1.08E+0	-1.09E+00
P-13	13	-3.40E-01	-3.38E-01	P 90-91	140	-1.40E-02	-1.39E-02
P-14	14	-1.40E-01	-1.38E-01	P 89-92	141	-1.98E+0	-1.94E+00
P-15	15	-9.00E-01	-8.95E-01	P 89-92	142	-6.20E-01	-6.28E-01
P-16	16	-2.50E-01	-2.48E-01	P 91-92	143	8.64E-02	8.53E-02
P-17	17	-1.10E-01	-1.08E-01	P 92-93	144	-5.67E-01	-5.76E-01
P-18	18	-6.00E-01	-6.05E-01	P 92-94	145	-5.07E-01	-5.02E-01
P-19	19	-4.50E-01	-4.51E-01	P 93-94	146	-4.42E-01	-4.44E-01
P-20	20	-1.80E-01	-1.78E-01	P 94-95	147	-4.06E-01	-4.04E-01
P-21	21	-1.40E-01	-1.39E-01	P 80-96	148	-1.87E-01	-1.89E-01
P-22	22	-1.00E-01	-1.01E-01	P 82-96	149	9.96E-02	1.01E-01
P-23	23	-7.00E-02	-6.91E-02	P 94-96	150	-1.97E-01	-1.95E-01
P-24	24	-1.30E-01	-1.32E-01	P 80-97	151	-2.62E-01	-2.58E-01
P-25	25	2.20E+00	2.24E+00	P 80-98	152	-2.87E-01	-2.84E-01

P-26	26	3.14E+00	3.10E+00	P 80-99	153	-1.94E-01	-1.95E-01
P-27	27	-7.10E-01	-7.01E-01	P 92-100	154	-3.07E-01	-3.13E-01
P-28	28	-1.70E-01	-1.70E-01	P 94-100	155	-3.87E-02	-3.90E-02
P-29	29	-2.40E-01	-2.38E-01	P 95-96	156	1.45E-02	1.48E-02
P-30	30	0.00E+00	0.00E+00	P 96-97	157	1.12E-01	1.12E-01
P-31	31	-3.60E-01	-3.66E-01	P 98-100	158	5.28E-02	5.30E-02
P-32	32	-5.90E-01	-5.92E-01	P 99-100	159	2.27E-01	2.24E-01
P-33	33	-2.30E-01	-2.31E-01	P 100-101	160	1.70E-01	1.73E-01
P-34	34	-5.90E-01	-5.96E-01	P 92-102	161	-4.44E-01	-4.43E-01
P-35	35	-3.30E-01	-3.30E-01	P 101-102	162	3.94E-01	3.99E-01
P-36	36	-3.10E-01	-3.04E-01	P 100-103	163	-1.19E+00	-1.19E+00
P-37	37	0.00E+00	0.00E+00	P 100-104	164	-5.47E-01	-5.52E-01
P-38	38	0.00E+00	0.00E+00	P 103-104	165	-3.19E-01	-3.23E-01
P-39	39	-2.70E-01	-2.69E-01	P 103-105	166	-4.22E-01	-4.17E-01
P-40	40	-6.60E-01	-6.69E-01	P 100-106	167	-5.81E-01	-5.74E-01
P-41	41	-3.70E-01	-3.74E-01	P 104-105	168	-4.83E-01	-4.85E-01
P-42	42	-9.60E-01	-9.69E-01	P 105-105	169	-8.85E-02	-8.75E-02
P-43	43	-1.80E-01	-1.79E-01	P 105-107	170	-2.63E-01	-2.67E-01
P-44	44	-1.60E-01	-1.58E-01	P 105-108	171	-2.38E-01	-2.41E-01
P-45	45	-5.30E-01	-5.20E-01	P 106-107	172	-2.37E-01	-2.38E-01
P-46	46	-9.00E-02	-8.84E-02	P 108-109	173	-2.17E-01	-2.14E-01
P-47	47	-3.40E-01	-3.46E-01	P 103-110	174	-5.91E-01	-5.90E-01
P-48	48	-2.00E-01	-1.98E-01	P 109-110	175	-1.36E-01	-1.36E-01
P-49	49	1.17E+00	1.16E+00	P 110-111	176	3.60E-01	3.54E-01
P-50	50	-1.70E-01	-1.71E-01	P 110-112	177	-6.80E-01	-6.69E-01
P-51	51	-1.70E-01	-1.73E-01	P 17-113	178	-2.05E-02	-2.02E-02
P-52	52	-1.80E-01	-1.81E-01	P 32-113	179	-3.95E-02	-3.90E-02
P-53	53	-2.30E-01	-2.32E-01	P 32-114	180	-9.36E-02	-9.34E-02
P-54	54	-6.50E-01	-6.48E-01	P 27-115	181	-2.06E-01	-2.10E-01
P-55	55	-6.30E-01	-6.40E-01	P 114-115	182	-1.36E-02	-1.33E-02
P-56	56	-8.40E-01	-8.38E-01	P 68-116	183	-1.84E+00	-1.83E+00
P-57	57	-1.20E-01	-1.21E-01	P 12-117	184	-2.00E-01	-2.03E-01
P-58	58	-1.20E-01	-1.21E-01	P 75-118	185	-3.99E-01	-4.04E-01
P-59	59	-1.22E+00	-1.21E+00	P 76-118	186	6.87E-02	6.81E-02
P-60	60	-7.80E-01	-7.88E-01	Q 1-2	1	-1.30E-01	-1.27E-01
P-61	61	1.60E+00	1.59E+00	Q 1-3	2	-1.71E-01	-1.67E-01
P-62	62	-7.70E-01	-7.84E-01	Q 4-5	3	-2.68E-01	-2.78E-01
P-63	63	0.00E+00	0.00E+00	Q 3-5	4	-1.45E-01	-1.48E-01
P-64	64	0.00E+00	0.00E+00	Q 5-6	5	4.11E-02	4.15E-02
P-65	65	3.91E+00	3.92E+00	Q 6-7	6	-4.77E-02	-4.93E-02
P-66	66	3.53E+00	3.57E+00	Q 8-9	7	-8.97E-01	-8.98E-01
P-67	67	-2.80E-01	-2.74E-01	Q 8-5	8	1.25E+00	1.29E+00
P-68	68	0.00E+00	0.00E+00	Q 9-10	9	-2.44E-01	-2.44E-01
P-69	69	5.14E+00	5.20E+00	Q 4-11	10	-2.18E-03	-2.14E-03
P-70	70	-6.60E-01	-6.50E-01	Q 5-11	11	2.97E-02	2.90E-02
P-71	71	0.00E+00	0.00E+00	Q 11-12	12	-3.51E-01	-3.55E-01
P-72	72	-1.20E-01	-1.18E-01	Q 2-12	13	-2.00E-01	-2.07E-01

P-73	73	-6.00E-02	-5.91E-02	Q 3-12	14	-1.24E-01	-1.21E-01
P-74	74	-6.80E-01	-6.72E-01	Q 7-12	15	-6.51E-02	-6.64E-02
P-75	75	-4.70E-01	-4.75E-01	Q 11-13	16	1.14E-01	1.18E-01
P-76	76	-6.80E-01	-6.80E-01	Q 12-14	17	2.62E-02	2.61E-02
P-77	77	-6.10E-01	-6.01E-01	Q 13-15	18	-3.84E-02	-3.92E-02
P-78	78	-7.10E-01	-7.17E-01	Q 14-15	19	3.14E-02	3.23E-02
P-79	79	-3.90E-01	-3.95E-01	Q 12-16	20	4.30E-02	4.33E-02
P-80	80	3.47E+00	3.46E+00	Q 15-17	21	-2.43E-01	-2.38E-01
P-81	81	0.00E+00	0.00E+00	Q 16-17	22	-3.68E-02	-3.54E-02
P-82	82	-5.40E-01	-5.35E-01	Q 17-18	23	2.48E-01	2.40E-01
P-83	83	-2.00E-01	-2.02E-01	Q 18-19	24	1.68E-01	1.73E-01
P-84	84	-1.10E-01	-1.12E-01	Q 19-20	25	5.17E-02	5.00E-02
P-85	85	-2.40E-01	-2.38E-01	Q 15-19	26	1.57E-01	1.63E-01
P-86	86	-2.10E-01	-2.10E-01	Q 20-21	27	4.71E-02	4.71E-02
P-87	87	4.00E-02	3.94E-02	Q 21-22	28	-2.10E-02	-2.14E-02
P-88	88	-4.80E-01	-4.73E-01	Q 22-23	29	-6.76E-02	-6.77E-02
P-89	89	6.07E+00	5.95E+00	Q 23-24	30	1.04E-01	1.06E-01
P-90	90	-1.63E+00	-1.64E+00	Q 23-25	31	-2.62E-01	-2.62E-01
P-91	91	-1.00E-01	-9.92E-02	Q 26-25	32	2.16E-01	2.12E-01
P-92	92	-6.50E-01	-6.44E-01	Q 25-27	33	3.01E-01	2.99E-01
P-93	93	-1.20E-01	-1.20E-01	Q 27-28	34	-5.92E-03	-6.00E-03
P-94	94	-3.00E-01	-3.02E-01	Q 28-29	35	-6.57E-02	-6.39E-02
P-95	95	-4.20E-01	-4.23E-01	Q 30-17	36	9.30E-01	9.58E-01
P-96	96	-3.80E-01	-3.75E-01	Q 8-30	37	2.81E-01	2.84E-01
P-97	97	-1.50E-01	-1.48E-01	Q 26-30	38	-1.15E-01	-1.18E-01
P-98	98	-3.40E-01	-3.43E-01	Q 17-31	39	1.15E-01	1.14E-01
P-99	99	-4.20E-01	-4.24E-01	Q 29-31	40	-8.64E-02	-8.60E-02
P-100	100	2.15E+00	2.14E+00	Q 23-32	41	5.05E-02	4.96E-02
P-101	101	-2.20E-01	-2.23E-01	Q 31-32	42	1.24E-01	1.21E-01
P-102	102	-5.00E-02	-4.91E-02	Q 27-32	43	1.76E-02	1.77E-02
P-103	103	1.70E-01	1.67E-01	Q 15-33	44	-4.42E-02	-4.54E-02
P-104	104	-3.80E-01	-3.73E-01	Q 19-34	45	-1.04E-01	-1.04E-01
P-105	105	-3.10E-01	-3.09E-01	Q 35-36	46	4.04E-02	4.00E-02
P-106	106	-4.30E-01	-4.26E-01	Q 35-37	47	-1.30E-01	-1.35E-01
P-107	107	-5.00E-01	-4.98E-01	Q 33-37	48	-1.05E-01	-1.08E-01
P-108	108	-2.00E-02	-2.00E-02	Q 34-36	49	4.70E-02	4.86E-02
P-109	109	-8.00E-02	-7.92E-02	Q 34-37	50	-4.42E-01	-4.53E-01
P-110	110	-3.90E-01	-3.97E-01	Q 38-37	51	1.14E+00	1.18E+00
P-111	111	3.60E-01	3.57E-01	Q 37-39	52	2.98E-02	2.96E-02
P-112	112	-6.80E-01	-6.72E-01	Q 37-40	53	-3.68E-02	-3.80E-02
P-113	113	-6.00E-02	-6.02E-02	Q 30-38	54	1.90E-01	1.84E-01
P-114	114	-8.00E-02	-8.08E-02	Q 39-40	55	-8.70E-02	-8.99E-02
P-115	115	-2.20E-01	-2.21E-01	Q 40-41	56	1.19E-02	1.16E-02
P-116	116	-1.84E+00	-1.87E+00	Q 40-42	57	-6.45E-02	-6.64E-02
P-117	117	-2.00E-01	-2.00E-01	Q 41-42	58	-7.79E-02	-7.62E-02
P-118	118	-3.30E-01	-3.32E-01	Q 43-44	59	-1.33E-02	-1.36E-02
Q-1	1	-3.01E-01	-3.03E-01	Q 34-43	60	1.63E-02	1.69E-02

Q-2	2	-9.00E-02	-8.91E-02	Q 44-45	61	5.48E-02	5.49E-02
Q-3	3	-1.00E-01	-1.03E-01	Q 45-46	62	-3.57E-02	-3.57E-02
Q-4	4	-2.70E-01	-2.76E-01	Q 46-47	63	-1.22E-02	-1.27E-02
Q-5	5	0.00E+00	0.00E+00	Q 46-48	64	-5.83E-02	-5.61E-02
Q-6	6	-6.07E-02	-6.00E-02	Q 47-49	65	-1.08E-01	-1.12E-01
Q-7	7	-2.00E-02	-1.97E-02	Q 42-49	66	5.24E-02	5.04E-02
Q-8	8	6.31E-01	6.28E-01	Q 42-49	67	5.24E-02	5.32E-02
Q-9	9	0.00E+00	0.00E+00	Q 45-49	68	-2.08E-02	-2.09E-02
Q-10	10	-5.10E-01	-5.05E-01	Q 48-49	69	3.21E-02	3.10E-02
Q-11	11	-2.30E-01	-2.24E-01	Q 49-50	70	1.34E-01	1.38E-01
Q-12	12	8.13E-01	8.38E-01	Q 49-51	71	2.04E-01	1.98E-01
Q-13	13	-1.60E-01	-1.64E-01	Q 51-52	72	6.25E-02	6.19E-02
Q-14	14	-1.00E-02	-1.01E-02	Q 52-53	73	1.99E-02	1.98E-02
Q-15	15	-2.28E-01	-2.33E-01	Q 53-54	74	-5.55E-02	-5.38E-02
Q-16	16	-1.00E-01	-1.03E-01	Q 49-54	75	1.31E-01	1.27E-01
Q-17	17	-3.00E-02	-2.94E-02	Q 49-54	76	1.12E-01	1.09E-01
Q-18	18	-5.57E-02	-5.64E-02	Q 54-55	77	1.46E-02	1.47E-02
Q-19	19	-3.93E-01	-4.08E-01	Q 54-56	78	4.35E-02	4.22E-02
Q-20	20	-3.00E-02	-3.01E-02	Q 55-56	79	-5.82E-02	-6.00E-02
Q-21	21	-8.00E-02	-8.13E-02	Q 56-57	80	-9.10E-02	-9.38E-02
Q-22	22	-5.00E-02	-5.08E-02	Q 50-57	81	9.14E-02	8.78E-02
Q-23	23	-3.00E-02	-3.06E-02	Q 56-58	82	-3.69E-02	-3.67E-02
Q-24	24	-1.49E-01	-1.52E-01	Q 51-58	83	3.16E-02	3.13E-02
Q-25	25	5.00E-01	5.17E-01	Q 54-59	84	-7.51E-02	-7.45E-02
Q-26	26	1.01E-01	1.00E-01	Q 56-59	85	-4.17E-02	-4.19E-02
Q-27	27	-9.02E-02	-8.79E-02	Q 56-59	86	-3.91E-02	-3.99E-02
Q-28	28	-7.00E-02	-6.74E-02	Q 55-59	87	-8.26E-02	-8.13E-02
Q-29	29	-4.00E-02	-3.86E-02	Q 59-60	88	3.57E-02	3.64E-02
Q-30	30	0.00E+00	0.00E+00	Q 59-61	89	5.03E-02	4.99E-02
Q-31	31	5.59E-02	5.79E-02	Q 60-61	90	8.52E-02	8.25E-02
Q-32	32	-3.93E-01	-3.84E-01	Q 60-62	91	-7.11E-02	-7.36E-02
Q-33	33	-9.00E-02	-8.83E-02	Q 61-62	92	-1.39E-01	-1.36E-01
Q-34	34	-4.68E-01	-4.66E-01	Q 63-59	93	6.75E-01	6.94E-01
Q-35	35	-9.00E-02	-9.09E-02	Q 63-64	94	-6.75E-01	-6.74E-01
Q-36	36	-9.27E-02	-9.59E-02	Q 64-61	95	1.40E-01	1.42E-01
Q-37	37	0.00E+00	0.00E+00	Q 38-65	96	-5.76E-01	-5.77E-01
Q-38	38	0.00E+00	0.00E+00	Q 64-65	97	-6.65E-01	-6.71E-01
Q-39	39	-1.10E-01	-1.06E-01	Q 49-66	98	4.33E-02	4.31E-02
Q-40	40	5.45E-02	5.26E-02	Q 49-66	99	4.33E-02	4.32E-02
Q-41	41	-1.00E-01	-1.01E-01	Q 62-66	100	-1.73E-01	-1.69E-01
Q-42	42	1.80E-01	1.82E-01	Q 62-67	101	-1.44E-01	-1.48E-01
Q-43	43	-7.00E-02	-6.74E-02	Q 65-66	102	7.22E-01	7.44E-01
Q-44	44	-8.00E-02	-7.80E-02	Q 66-67	103	1.93E-01	1.94E-01
Q-45	45	-2.20E-01	-2.14E-01	Q 65-68	104	-2.24E-01	-2.25E-01
Q-46	46	-1.50E-01	-1.52E-01	Q 47-69	105	1.16E-01	1.17E-01
Q-47	47	0.00E+00	0.00E+00	Q 49-69	106	1.06E-01	1.08E-01
Q-48	48	-1.10E-01	-1.12E-01	Q 68-69	107	1.13E+00	1.14E+00

Q-49	49	8.58E-01	8.28E-01	Q 69-70	108	1.61E-01	1.58E-01
Q-50	50	-4.00E-02	-4.09E-02	Q 24-70	109	-2.97E-02	-3.04E-02
Q-51	51	-8.00E-02	-8.07E-02	Q 70-71	110	-1.24E-01	-1.24E-01
Q-52	52	-5.00E-02	-4.87E-02	Q 24-72	111	3.31E-02	3.31E-02
Q-53	53	-1.10E-01	-1.08E-01	Q 71-72	112	-9.40E-03	-9.35E-03
Q-54	54	-2.81E-01	-2.78E-01	Q 71-73	113	-1.07E-01	-1.07E-01
Q-55	55	-1.73E-01	-1.74E-01	Q 70-74	114	1.29E-01	1.30E-01
Q-56	56	-2.03E-01	-2.10E-01	Q 70-75	115	9.94E-02	9.98E-02
Q-57	57	-3.00E-02	-2.96E-02	Q 69-75	116	2.05E-01	2.12E-01
Q-58	58	-3.00E-02	-2.99E-02	Q 74-75	117	-6.19E-02	-6.04E-02
Q-59	59	-3.62E-01	-3.76E-01	Q 76-77	118	-2.10E-01	-2.10E-01
Q-60	60	-3.00E-02	-2.91E-02	Q 69-77	119	6.78E-02	6.62E-02
Q-61	61	-4.04E-01	-3.93E-01	Q 75-77	120	-9.55E-02	-9.59E-02
Q-62	62	-1.27E-01	-1.29E-01	Q 77-78	121	6.61E-02	6.48E-02
Q-63	63	0.00E+00	0.00E+00	Q 78-79	122	-1.84E-01	-1.82E-01
Q-64	64	0.00E+00	0.00E+00	Q 77-80	123	-3.74E-01	-3.74E-01
Q-65	65	8.15E-01	8.32E-01	Q 77-80	124	-2.05E-01	-2.11E-01
Q-66	66	-2.00E-01	-2.03E-01	Q 79-80	125	-2.96E-01	-2.92E-01
Q-67	67	-7.00E-02	-7.22E-02	Q 68-81	126	-4.61E-02	-4.53E-02
Q-68	68	0.00E+00	0.00E+00	Q 81-80	127	7.55E-01	7.38E-01
Q-69	69	-8.24E-01	-8.07E-01	Q 77-82	128	1.76E-01	1.76E-01
Q-70	70	-1.03E-01	-1.05E-01	Q 82-83	129	2.44E-01	2.35E-01
Q-71	71	0.00E+00	0.00E+00	Q 83-84	130	1.47E-01	1.52E-01
Q-72	72	-1.11E-01	-1.08E-01	Q 83-85	131	1.20E-01	1.24E-01
Q-73	73	9.65E-02	9.62E-02	Q 84-85	132	8.99E-02	8.95E-02
Q-74	74	-3.26E-01	-3.27E-01	Q 85-86	133	-7.35E-02	-7.27E-02
Q-75	75	-1.10E-01	-1.13E-01	Q 86-87	134	-1.51E-01	-1.56E-01
Q-76	76	-3.07E-01	-3.04E-01	Q 85-88	135	7.60E-02	7.31E-02
Q-77	77	-1.58E-01	-1.63E-01	Q 85-89	136	6.77E-03	6.84E-03
Q-78	78	-2.60E-01	-2.60E-01	Q 88-89	137	-2.47E-02	-2.50E-02
Q-79	79	-3.20E-01	-3.17E-01	Q 89-90	138	-4.72E-02	-4.56E-02
Q-80	80	7.95E-01	8.01E-01	Q 89-90	139	-5.44E-02	-5.34E-02
Q-81	81	0.00E+00	0.00E+00	Q 90-91	140	4.42E-02	4.48E-02
Q-82	82	-2.70E-01	-2.69E-01	Q 89-92	141	-2.10E-02	-2.18E-02
Q-83	83	-1.00E-01	-9.72E-02	Q 89-92	142	-5.07E-02	-5.08E-02
Q-84	84	-7.00E-02	-6.94E-02	Q 91-92	143	-6.63E-02	-6.63E-02
Q-85	85	-2.06E-01	-2.07E-01	Q 92-93	144	-1.17E-01	-1.14E-01
Q-86	86	-1.00E-01	-9.89E-02	Q 92-94	145	-1.52E-01	-1.54E-01
Q-87	87	1.10E-01	1.10E-01	Q 93-94	146	-1.95E-01	-1.97E-01
Q-88	88	-1.00E-01	-9.67E-02	Q 94-95	147	9.01E-02	9.34E-02
Q-89	89	-5.90E-02	-5.84E-02	Q 80-96	148	2.11E-01	2.08E-01
Q-90	90	1.73E-01	1.75E-01	Q 82-96	149	-6.57E-02	-6.48E-02
Q-91	91	-1.31E-01	-1.34E-01	Q 94-96	150	-9.82E-02	-9.89E-02
Q-92	92	-2.40E-01	-2.31E-01	Q 80-97	151	2.58E-01	2.56E-01
Q-93	93	-7.00E-02	-6.92E-02	Q 80-98	152	8.32E-02	8.63E-02
Q-94	94	-1.60E-01	-1.62E-01	Q 80-99	153	8.17E-02	8.43E-02
Q-95	95	-3.10E-01	-3.03E-01	Q 92-100	154	-1.65E-01	-1.71E-01

Q-96	96	-1.50E-01	-1.48E-01	Q 94-100	155	-5.05E-01	-5.08E-01
Q-97	97	-9.00E-02	-9.31E-02	Q 95-96	156	-2.17E-01	-2.19E-01
Q-98	98	-8.00E-02	-8.25E-02	Q 96-97	157	-2.02E-01	-2.09E-01
Q-99	99	-1.75E-01	-1.68E-01	Q 98-100	158	2.43E-02	2.38E-02
Q-100	100	7.76E-01	7.91E-01	Q 99-100	159	-4.59E-02	-4.67E-02
Q-101	101	-1.50E-01	-1.46E-01	Q 100-101	160	2.29E-01	2.32E-01
Q-102	102	-3.00E-02	-2.98E-02	Q 92-102	161	-8.39E-02	-8.51E-02
Q-103	103	5.94E-01	5.83E-01	Q 101-102	162	1.01E-01	1.03E-01
Q-104	104	-2.26E-01	-2.25E-01	Q 100-103	163	-2.21E-01	-2.17E-01
Q-105	105	-4.43E-01	-4.47E-01	Q 100-104	164	1.06E-01	1.05E-01
Q-106	106	-1.60E-01	-1.58E-01	Q 103-104	165	1.39E-01	1.34E-01
Q-107	107	-5.44E-02	-5.30E-02	Q 103-105	166	1.28E-01	1.32E-01
Q-108	108	-1.00E-02	-1.00E-02	Q 100-106	167	9.48E-02	9.13E-02
Q-109	109	-3.00E-02	-2.91E-02	Q 104-105	168	2.63E-02	2.59E-02
Q-110	110	-2.97E-01	-2.86E-01	Q 105-105	169	3.88E-02	3.87E-02
Q-111	111	-1.84E-02	-1.86E-02	Q 105-107	170	-2.37E-02	-2.42E-02
Q-112	112	2.85E-01	2.81E-01	Q 105-108	171	-1.11E-01	-1.07E-01
Q-113	113	6.75E-02	6.95E-02	Q 106-107	172	-3.73E-02	-3.61E-02
Q-114	114	-3.00E-02	-2.97E-02	Q 108-109	173	-1.09E-01	-1.13E-01
Q-115	115	-7.00E-02	-7.25E-02	Q 103-110	174	8.35E-02	8.04E-02
Q-116	116	5.13E-01	4.98E-01	Q 109-110	175	-1.34E-01	-1.39E-01
Q-117	117	-8.00E-02	-8.00E-02	Q 110-111	176	9.56E-03	9.67E-03
Q-118	118	-1.50E-01	-1.54E-01	Q 110-112	177	-3.06E-01	-2.98E-01
P 1-2	1	-1.24E-01	-1.25E-01	Q 17-113	178	5.90E-02	5.66E-02
P 1-3	2	-3.86E-01	-3.79E-01	Q 32-113	179	-1.78E-01	-1.74E-01
P 4-5	3	-1.03E+00	-1.02E+00	Q 32-114	180	1.78E-02	1.74E-02
P 3-5	4	-6.81E-01	-6.75E-01	Q 27-115	181	5.06E-02	5.16E-02
P 5-6	5	8.85E-01	8.77E-01	Q 114-115	182	2.21E-03	2.15E-03
P 6-7	6	3.55E-01	3.61E-01	Q 68-116	183	-6.64E-01	-6.62E-01
P 8-9	7	-4.41E+00	-4.36E+00	Q 12-117	184	5.20E-02	5.29E-02
P 8-5	8	3.38E+00	3.35E+00	Q 75-118	185	2.36E-01	2.42E-01
P 9-10	9	-4.45E+00	-4.44E+00	Q 76-118	186	-9.69E-02	-9.95E-02
P 4-11	10	6.42E-01	6.42E-01	Q 1-2	1	1.10E-01	1.13E-01
P 5-11	11	7.72E-01	7.81E-01	Q 1-3	2	1.69E-01	1.62E-01
P 11-12	12	3.43E-01	3.46E-01	Q 4-5	3	2.75E-01	2.67E-01
P 2-12	13	-3.25E-01	-3.31E-01	Q 3-5	4	1.73E-01	1.70E-01
P 3-12	14	-9.79E-02	-9.97E-02	Q 5-6	5	-1.30E-02	-1.35E-02
P 7-12	15	1.65E-01	1.62E-01	Q 6-7	6	4.51E-02	4.58E-02
P 11-13	16	3.51E-01	3.49E-01	Q 8-9	7	2.44E-01	2.35E-01
P 12-14	17	1.83E-01	1.84E-01	Q 8-5	8	-9.20E-01	-9.26E-01
P 13-15	18	7.68E-03	7.64E-03	Q 9-10	9	-5.10E-01	-5.17E-01
P 14-15	19	4.24E-02	4.22E-02	Q 4-11	10	1.35E-02	1.33E-02
P 12-16	20	7.51E-02	7.63E-02	Q 5-11	11	-6.21E-03	-6.30E-03
P 15-17	21	-1.04E+00	-1.04E+00	Q 11-12	12	3.51E-01	3.38E-01
P 16-17	22	-1.75E-01	-1.72E-01	Q 2-12	13	1.94E-01	1.97E-01
P 17-18	23	8.03E-01	8.07E-01	Q 3-12	14	8.86E-02	8.79E-02
P 18-19	24	1.94E-01	1.93E-01	Q 7-12	15	5.76E-02	5.88E-02

P 19-20	25	-1.06E-01	-1.06E-01	Q 11-13	16	-1.22E-01	-1.26E-01
P 15-19	26	1.15E-01	1.16E-01	Q 12-14	17	-4.14E-02	-4.04E-02
P 20-21	27	-2.87E-01	-2.92E-01	Q 13-15	18	-2.04E-02	-2.02E-02
P 21-22	28	-4.28E-01	-4.37E-01	Q 14-15	19	-7.83E-02	-7.64E-02
P 22-23	29	-5.33E-01	-5.27E-01	Q 12-16	20	-6.32E-02	-6.19E-02
P 23-24	30	8.28E-02	8.28E-02	Q 15-17	21	2.52E-01	2.55E-01
P 23-25	31	-1.63E+00	-1.64E+00	Q 16-17	22	-3.04E-03	-3.00E-03
P 26-25	32	9.03E-01	8.92E-01	Q 17-18	23	-2.24E-01	-2.29E-01
P 25-27	33	1.44E+00	1.45E+00	Q 18-19	24	-1.75E-01	-1.72E-01
P 27-28	34	3.29E-01	3.34E-01	Q 19-20	25	-7.71E-02	-7.75E-02
P 28-29	35	1.57E-01	1.56E-01	Q 15-19	26	-1.65E-01	-1.61E-01
P 30-17	36	2.31E+00	2.27E+00	Q 20-21	27	-5.90E-02	-5.78E-02
P 8-30	37	7.42E-01	7.54E-01	Q 21-22	28	1.76E-02	1.79E-02
P 26-30	38	2.24E+00	2.24E+00	Q 22-23	29	7.69E-02	7.49E-02
P 17-31	39	1.48E-01	1.47E-01	Q 23-24	30	-1.52E-01	-1.54E-01
P 29-31	40	-8.42E-02	-8.54E-02	Q 23-25	31	3.86E-01	3.79E-01
P 23-32	41	9.30E-01	9.36E-01	Q 26-25	32	-1.86E-01	-1.92E-01
P 31-32	42	-2.99E-01	-2.97E-01	Q 25-27	33	-1.53E-01	-1.48E-01
P 27-32	43	1.25E-01	1.25E-01	Q 27-28	34	-4.32E-03	-4.42E-03
P 15-33	44	7.31E-02	7.38E-02	Q 28-29	35	4.64E-02	4.76E-02
P 19-34	45	-3.59E-02	-3.59E-02	Q 30-17	36	-7.01E-01	-6.94E-01
P 35-36	46	8.39E-03	8.28E-03	Q 8-30	37	-7.54E-01	-7.83E-01
P 35-37	47	-3.38E-01	-3.33E-01	Q 26-30	38	-3.66E-01	-3.66E-01
P 33-37	48	-1.57E-01	-1.55E-01	Q 17-31	39	-1.47E-01	-1.47E-01
P 34-36	49	3.02E-01	2.98E-01	Q 29-31	40	7.92E-02	8.03E-02
P 34-37	50	-9.43E-01	-9.48E-01	Q 23-32	41	-6.24E-02	-6.17E-02
P 38-37	51	2.43E+00	2.43E+00	Q 31-32	42	-1.36E-01	-1.40E-01
P 37-39	52	5.49E-01	5.43E-01	Q 27-32	43	-3.43E-02	-3.49E-02
P 37-40	53	4.40E-01	4.32E-01	Q 15-33	44	1.49E-02	1.48E-02
P 30-38	54	6.24E-01	6.30E-01	Q 19-34	45	4.60E-02	4.52E-02
P 39-40	55	2.69E-01	2.71E-01	Q 35-36	46	-4.29E-02	-4.22E-02
P 40-41	56	1.54E-01	1.57E-01	Q 35-37	47	1.24E-01	1.22E-01
P 40-42	57	-1.18E-01	-1.17E-01	Q 33-37	48	7.46E-02	7.68E-02
P 41-42	58	-2.16E-01	-2.19E-01	Q 34-36	49	-4.98E-02	-4.81E-02
P 43-44	59	-1.66E-01	-1.66E-01	Q 34-37	50	4.43E-01	4.31E-01
P 34-43	60	1.41E-02	1.40E-02	Q 38-37	51	-8.80E-01	-9.04E-01
P 44-45	61	-3.28E-01	-3.33E-01	Q 37-39	52	-2.30E-02	-2.31E-02
P 45-46	62	-3.63E-01	-3.62E-01	Q 37-40	53	2.96E-02	2.90E-02
P 46-47	63	-3.11E-01	-3.10E-01	Q 30-38	54	-5.60E-01	-5.40E-01
P 46-48	64	-1.48E-01	-1.47E-01	Q 39-40	55	7.75E-02	7.61E-02
P 47-49	65	-9.54E-02	-9.47E-02	Q 40-41	56	-2.21E-02	-2.21E-02
P 42-49	66	-6.49E-01	-6.44E-01	Q 40-42	57	2.30E-02	2.21E-02
P 42-49	67	-6.49E-01	-6.55E-01	Q 41-42	58	5.24E-02	5.27E-02
P 45-49	68	-4.97E-01	-4.87E-01	Q 43-44	59	-3.79E-02	-3.65E-02
P 48-49	69	-3.49E-01	-3.55E-01	Q 34-43	60	-5.67E-02	-5.59E-02
P 49-50	70	5.37E-01	5.46E-01	Q 44-45	61	-6.62E-02	-6.63E-02
P 49-51	71	6.66E-01	6.70E-01	Q 45-46	62	2.12E-02	2.18E-02

P 51-52	72	2.86E-01	2.85E-01	Q 46-47	63	-7.95E-03	-8.03E-03
P 52-53	73	1.04E-01	1.03E-01	Q 46-48	64	1.42E-02	1.41E-02
P 53-54	74	-1.27E-01	-1.27E-01	Q 47-49	65	9.28E-02	9.10E-02
P 49-54	75	3.78E-01	3.71E-01	Q 42-49	66	3.70E-03	3.70E-03
P 49-54	76	3.77E-01	3.83E-01	Q 42-49	67	3.70E-03	3.77E-03
P 54-55	77	7.07E-02	7.14E-02	Q 45-49	68	2.31E-02	2.29E-02
P 54-56	78	1.85E-01	1.82E-01	Q 48-49	69	-3.93E-02	-3.88E-02
P 55-56	79	-2.14E-01	-2.12E-01	Q 49-50	70	-1.31E-01	-1.30E-01
P 56-57	80	-2.30E-01	-2.26E-01	Q 49-51	71	-1.74E-01	-1.78E-01
P 50-57	81	3.59E-01	3.63E-01	Q 51-52	72	-6.99E-02	-7.21E-02
P 56-58	82	-6.67E-02	-6.78E-02	Q 52-53	73	-5.45E-02	-5.30E-02
P 51-58	83	1.88E-01	1.89E-01	Q 53-54	74	2.99E-02	3.04E-02
P 54-59	84	-3.04E-01	-3.05E-01	Q 49-54	75	-1.56E-01	-1.58E-01
P 56-59	85	-2.80E-01	-2.75E-01	Q 49-54	76	-1.38E-01	-1.42E-01
P 56-59	86	-2.93E-01	-2.90E-01	Q 54-55	77	-3.25E-02	-3.20E-02
P 55-59	87	-3.45E-01	-3.48E-01	Q 54-56	78	-4.98E-02	-4.96E-02
P 59-60	88	-4.33E-01	-4.37E-01	Q 55-56	79	5.57E-02	5.38E-02
P 59-61	89	-5.17E-01	-5.16E-01	Q 56-57	80	7.49E-02	7.60E-02
P 60-61	90	-1.12E+00	-1.14E+00	Q 50-57	81	-1.05E-01	-1.01E-01
P 60-62	91	-9.87E-02	-1.00E-01	Q 56-58	82	1.53E-02	1.53E-02
P 61-62	92	2.55E-01	2.54E-01	Q 51-58	83	-4.53E-02	-4.56E-02
P 63-59	93	1.52E+00	1.50E+00	Q 54-59	84	4.26E-02	4.32E-02
P 63-64	94	-1.52E+00	-1.53E+00	Q 56-59	85	9.87E-03	9.84E-03
P 64-61	95	3.05E-01	3.11E-01	Q 56-59	86	1.13E-02	1.13E-02
P 38-65	96	-1.81E+00	-1.84E+00	Q 55-59	87	5.88E-02	5.83E-02
P 64-65	97	-1.83E+00	-1.86E+00	Q 59-60	88	-4.40E-02	-4.37E-02
P 49-66	98	-1.32E+00	-1.31E+00	Q 59-61	89	-4.63E-02	-4.76E-02
P 49-66	99	-1.32E+00	-1.34E+00	Q 60-61	90	-8.23E-02	-8.31E-02
P 62-66	100	-3.72E-01	-3.76E-01	Q 60-62	91	5.74E-02	5.96E-02
P 62-67	101	-2.43E-01	-2.39E-01	Q 61-62	92	1.32E-01	1.35E-01
P 65-66	102	8.54E-02	8.42E-02	Q 63-59	93	-5.70E-01	-5.86E-01
P 66-67	103	5.32E-01	5.39E-01	Q 63-64	94	5.25E-01	5.08E-01
P 65-68	104	1.42E-01	1.44E-01	Q 64-61	95	-1.37E-01	-1.39E-01
P 47-69	105	-5.59E-01	-5.52E-01	Q 38-65	96	-8.37E-02	-8.05E-02
P 49-69	106	-4.65E-01	-4.70E-01	Q 64-65	97	4.01E-01	3.99E-01
P 68-69	107	-1.26E+00	-1.27E+00	Q 49-66	98	8.32E-02	8.53E-02
P 69-70	108	1.08E+00	1.10E+00	Q 49-66	99	8.32E-02	8.61E-02
P 24-70	109	-6.22E-02	-6.30E-02	Q 62-66	100	1.47E-01	1.51E-01
P 70-71	110	1.67E-01	1.69E-01	Q 62-67	101	1.21E-01	1.23E-01
P 24-72	111	1.47E-02	1.48E-02	Q 65-66	102	-7.06E-01	-6.97E-01
P 71-72	112	1.06E-01	1.07E-01	Q 66-67	103	-1.91E-01	-1.92E-01
P 71-73	113	6.01E-02	5.92E-02	Q 65-68	104	-4.18E-01	-4.15E-01
P 70-74	114	1.62E-01	1.63E-01	Q 47-69	105	-1.01E-01	-9.67E-02
P 70-75	115	-1.33E-03	-1.32E-03	Q 49-69	106	-1.21E-01	-1.24E-01
P 69-75	116	1.10E+00	1.10E+00	Q 68-69	107	-1.04E+00	-1.00E+00
P 74-75	117	-5.20E-01	-5.13E-01	Q 69-70	108	-1.40E-01	-1.42E-01
P 76-77	118	-6.12E-01	-6.19E-01	Q 24-70	109	-6.80E-02	-7.01E-02

P 69-77	119	6.22E-01	6.26E-01	Q 70-71	110	1.17E-01	1.15E-01
P 75-77	120	-3.46E-01	-3.46E-01	Q 24-72	111	-7.98E-02	-7.76E-02
P 77-78	121	4.54E-01	4.51E-01	Q 71-72	112	-3.15E-02	-3.24E-02
P 78-79	122	-2.57E-01	-2.60E-01	Q 71-73	113	9.65E-02	9.84E-02
P 77-80	123	-9.66E-01	-9.70E-01	Q 70-74	114	-1.54E-01	-1.60E-01
P 77-80	124	-4.44E-01	-4.49E-01	Q 70-75	115	-1.32E-01	-1.28E-01
P 79-80	125	-6.47E-01	-6.54E-01	Q 69-75	116	-1.83E-01	-1.81E-01
P 68-81	126	-4.41E-01	-4.42E-01	Q 74-75	117	6.44E-02	6.50E-02
P 81-80	127	-4.42E-01	-4.44E-01	Q 76-77	118	2.44E-01	2.39E-01
P 77-82	128	-3.03E-02	-3.04E-02	Q 69-77	119	-1.38E-01	-1.37E-01
P 82-83	129	-4.72E-01	-4.66E-01	Q 75-77	120	7.38E-02	7.60E-02
P 83-84	130	-2.48E-01	-2.45E-01	Q 77-78	121	-7.63E-02	-7.47E-02
P 83-85	131	-4.28E-01	-4.28E-01	Q 78-79	122	1.80E-01	1.85E-01
P 84-85	132	-3.63E-01	-3.68E-01	Q 77-80	123	3.75E-01	3.75E-01
P 85-86	133	1.72E-01	1.72E-01	Q 77-80	124	2.06E-01	2.05E-01
P 86-87	134	-3.95E-02	-3.92E-02	Q 79-80	125	3.11E-01	2.99E-01
P 85-88	135	-5.04E-01	-4.94E-01	Q 68-81	126	-7.55E-01	-7.36E-01
P 85-89	136	-7.12E-01	-7.22E-01	Q 81-80	127	-7.30E-01	-7.29E-01
P 88-89	137	-9.89E-01	-9.96E-01	Q 77-82	128	-2.53E-01	-2.44E-01
P 89-90	138	5.82E-01	5.85E-01	Q 82-83	129	-2.70E-01	-2.70E-01
P 89-90	139	1.11E+00	1.11E+00	Q 83-84	130	-1.60E-01	-1.60E-01
P 90-91	140	1.41E-02	1.44E-02	Q 83-85	131	-1.23E-01	-1.28E-01
P 89-92	141	2.02E+00	1.98E+00	Q 84-85	132	-9.24E-02	-9.38E-02
P 89-92	142	6.36E-01	6.33E-01	Q 85-86	133	5.09E-02	4.97E-02
P 91-92	143	-8.60E-02	-8.50E-02	Q 86-87	134	1.10E-01	1.11E-01
P 92-93	144	5.76E-01	5.73E-01	Q 85-88	135	-7.53E-02	-7.42E-02
P 92-94	145	5.22E-01	5.26E-01	Q 85-89	136	3.73E-02	3.79E-02
P 93-94	146	4.47E-01	4.49E-01	Q 88-89	137	7.70E-02	7.56E-02
P 94-95	147	4.09E-01	4.12E-01	Q 89-90	138	5.81E-02	5.79E-02
P 80-96	148	1.90E-01	1.91E-01	Q 89-90	139	7.07E-02	7.25E-02
P 82-96	149	-9.94E-02	-9.79E-02	Q 90-91	140	-6.46E-02	-6.27E-02
P 94-96	150	1.98E-01	1.97E-01	Q 89-92	141	1.70E-01	1.72E-01
P 80-97	151	2.64E-01	2.62E-01	Q 89-92	142	7.29E-02	7.54E-02
P 80-98	152	2.89E-01	2.87E-01	Q 91-92	143	3.59E-02	3.49E-02
P 80-99	153	1.96E-01	1.94E-01	Q 92-93	144	1.25E-01	1.30E-01
P 92-100	154	3.15E-01	3.21E-01	Q 92-94	145	1.59E-01	1.63E-01
P 94-100	155	4.28E-02	4.21E-02	Q 93-94	146	1.94E-01	1.99E-01
P 95-96	156	-1.38E-02	-1.36E-02	Q 94-95	147	-9.31E-02	-8.96E-02
P 96-97	157	-1.11E-01	-1.11E-01	Q 80-96	148	-2.46E-01	-2.55E-01
P 98-100	158	-5.26E-02	-5.17E-02	Q 82-96	149	1.29E-02	1.26E-02
P 99-100	159	-2.26E-01	-2.23E-01	Q 94-96	150	7.98E-02	7.99E-02
P 100-101	160	-1.67E-01	-1.70E-01	Q 80-97	151	-2.72E-01	-2.69E-01
P 92-102	161	4.47E-01	4.38E-01	Q 80-98	152	-1.04E-01	-1.04E-01
P 101-102	162	-3.90E-01	-3.88E-01	Q 80-99	153	-1.29E-01	-1.33E-01
P 100-103	163	1.22E+00	1.21E+00	Q 92-100	154	1.54E-01	1.53E-01
P 100-104	164	5.62E-01	5.61E-01	Q 94-100	155	4.58E-01	4.46E-01
P 103-104	165	3.25E-01	3.27E-01	Q 95-96	156	2.05E-01	2.01E-01

P 103-105	166	4.34E-01	4.28E-01	Q 96-97	157	1.82E-01	1.88E-01
P 100-106	167	6.04E-01	5.93E-01	Q 98-100	158	-7.30E-02	-7.13E-02
P 104-105	168	4.86E-01	4.93E-01	Q 99-100	159	2.79E-02	2.87E-02
P 105-105	169	8.86E-02	8.84E-02	Q 100-101	160	-2.51E-01	-2.44E-01
P 105-107	170	2.68E-01	2.64E-01	Q 92-102	161	8.13E-02	8.03E-02
P 105-108	171	2.40E-01	2.40E-01	Q 101-102	162	-1.11E-01	-1.10E-01
P 106-107	172	2.40E-01	2.39E-01	Q 100-103	163	2.44E-01	2.37E-01
P 108-109	173	2.18E-01	2.15E-01	Q 100-104	164	-9.41E-02	-9.54E-02
P 103-110	174	6.06E-01	6.01E-01	Q 103-104	165	-1.58E-01	-1.56E-01
P 109-110	175	1.37E-01	1.39E-01	Q 103-105	166	-1.35E-01	-1.31E-01
P 110-111	176	-3.57E-01	-3.58E-01	Q 100-106	167	-7.12E-02	-7.11E-02
P 110-112	177	6.95E-01	6.85E-01	Q 104-105	168	-2.61E-02	-2.60E-02
P 17-113	178	2.06E-02	2.06E-02	Q 105-105	169	-5.15E-02	-5.06E-02
P 32-113	179	4.12E-02	4.12E-02	Q 105-107	170	-5.55E-03	-5.54E-03
P 32-114	180	9.37E-02	9.44E-02	Q 105-108	171	9.92E-02	1.01E-01
P 27-115	181	2.07E-01	2.10E-01	Q 106-107	172	5.51E-03	5.31E-03
P 114-115	182	1.36E-02	1.38E-02	Q 108-109	173	1.04E-01	1.05E-01
P 68-116	183	1.84E+00	1.86E+00	Q 103-110	174	-6.15E-02	-6.34E-02
P 12-117	184	2.02E-01	2.00E-01	Q 109-110	175	1.18E-01	1.14E-01
P 75-118	185	4.02E-01	3.95E-01	Q 110-111	176	-1.84E-02	-1.86E-02
P 76-118	186	-6.85E-02	-6.76E-02	Q 110-112	177	2.85E-01	2.93E-01
P 1-2	1	1.25E-01	1.25E-01	Q 17-113	178	-6.65E-02	-6.50E-02
P 1-3	2	3.89E-01	3.84E-01	Q 32-113	179	1.34E-01	1.34E-01
P 4-5	3	1.03E+00	1.04E+00	Q 32-114	180	-3.22E-02	-3.22E-02
P 3-5	4	6.93E-01	6.99E-01	Q 27-115	181	-6.53E-02	-6.50E-02
P 5-6	5	-8.75E-01	-8.74E-01	Q 114-115	182	-4.75E-03	-4.57E-03
P 6-7	6	-3.55E-01	-3.52E-01	Q 68-116	183	5.13E-01	4.93E-01
P 8-9	7	4.45E+00	4.40E+00	Q 12-117	184	-8.00E-02	-7.70E-02
P 8-5	8	-3.38E+00	-3.35E+00	Q 75-118	185	-2.36E-01	-2.43E-01
P 9-10	9	4.50E+00	4.50E+00	Q 76-118	186	8.56E-02	8.53E-02

A.3.5. SCADA Meter Distribution for 118-bus Test Case

Table 0.12 SCADA Meter Distribution for 118-Bus System Test Case

Voltage Magnitude		Real Power Injections		Reactive Power Injections		Real Power Flows		Reactive Power Flows	
Type	Index	Type	Index	Type	Index	Type	Index	Type	Index
Vm-2	2	P-3	3	Q-3	3	P1-2	1	Q1-2	1
Vm-3	3	P-4	4	Q-4	4	P3-5	4	Q3-5	4
Vm-4	4	P-8	8	Q-8	8	P5-6	5	Q5-6	5
Vm-5	5	P-9	9	Q-9	9	P6-7	6	Q6-7	6
Vm-9	9	P-12	12	Q-12	12	P9-10	9	Q9-10	9
Vm-12	12	P-13	13	Q-13	13	P4-11	10	Q4-11	10
Vm-15	15	P-15	15	Q-15	15	P5-11	11	Q5-11	11
Vm-17	17	P-16	16	Q-16	16	P2-12	13	Q2-12	13

Vm-18	18	P-19	19	Q-19	19	P7-12	15	Q7-12	15
Vm-21	21	P-20	20	Q-20	20	P12-14	17	Q12-14	17
Vm-23	23	P-24	24	Q-24	24	P14-15	19	Q14-15	19
Vm-24	24	P-25	25	Q-25	25	P17-18	23	Q17-18	23
Vm-25	25	P-30	30	Q-30	30	P21-22	28	Q21-22	28
Vm-27	27	P-31	31	Q-31	31	P23-24	30	Q23-24	30
Vm-28	28	P-33	33	Q-33	33	P28-29	35	Q28-29	35
Vm-29	29	P-35	35	Q-35	35	P30-17	36	Q30-17	36
Vm-30	30	P-36	36	Q-36	36	P17-31	39	Q17-31	39
Vm-34	34	P-38	38	Q-37	37	P23-32	41	Q23-32	41
Vm-36	36	P-42	42	Q-38	38	P34-36	49	Q34-36	49
Vm-37	37	P-44	44	Q-42	42	P37-40	53	Q37-40	53
Vm-40	40	P-46	46	Q-44	44	P39-40	55	Q39-40	55
Vm-42	42	P-47	47	Q-46	46	P40-41	56	Q40-41	56
Vm-44	44	P-49	49	Q-47	47	P43-44	59	Q43-44	59
Vm-45	45	P-52	52	Q-49	49	P34-43	60	Q34-43	60
Vm-46	46	P-53	53	Q-52	52	P46-48	64	Q46-48	64
Vm-49	49	P-54	54	Q-53	53	P45-49	68	Q45-49	68
Vm-51	51	P-55	55	Q-54	54	P52-53	73	Q52-53	73
Vm-53	53	P-61	61	Q-55	55	P54-55	77	Q54-55	77
Vm-54	54	P-63	63	Q-61	61	P56-57	80	Q56-57	80
Vm-56	56	P-64	64	Q-63	63	P50-57	81	Q50-57	81
Vm-57	57	P-66	66	Q-64	64	P51-58	83	Q51-58	83
Vm-59	59	P-68	68	Q-66	66	P59-60	88	Q59-60	88
Vm-62	62	P-70	70	Q-68	68	P60-62	91	Q60-62	91
Vm-63	63	P-71	71	Q-70	70	P64-65	97	Q64-65	97
Vm-64	64	P-77	77	Q-71	71	P62-67	101	Q62-67	101
Vm-68	68	P-79	79	Q-77	77	P65-68	104	Q65-68	104
Vm-69	69	P-81	81	Q-79	79	P47-69	105	Q47-69	105
Vm-70	70	P-83	83	Q-81	81	P71-72	112	Q71-72	112
Vm-71	71	P-85	85	Q-83	83	P71-73	113	Q71-73	113
Vm-73	73	P-86	86	Q-85	85	P69-75	116	Q69-75	116
Vm-75	75	P-90	90	Q-86	86	P74-75	117	Q74-75	117
Vm-76	76	P-92	92	Q-89	89	P76-77	118	Q76-77	118
Vm-77	77	P-96	96	Q-90	90	P78-79	122	Q78-79	122
Vm-80	80	P-97	97	Q-92	92	P81-80	127	Q81-80	127
Vm-82	82	P-98	98	Q-96	96	P77-82	128	Q77-82	128
Vm-85	85	P-99	99	Q-97	97	P84-85	132	Q84-85	132
Vm-86	86	P-102	102	Q-98	98	P86-87	134	Q86-87	134
Vm-91	91	P-104	104	Q-99	99	P85-88	135	Q85-88	135
Vm-92	92	P-105	105	Q-102	102	P91-92	143	Q91-92	143
Vm-94	94	P-110	110	Q-104	104	P92-93	144	Q92-93	144
Vm-100	100	P-111	111	Q-105	105	P94-95	147	Q94-95	147
Vm-101	101	P-112	112	Q-110	110	P82-96	149	Q82-96	149
Vm-102	102	P-116	116	Q-111	111	P92-100	154	Q92-100	154
Vm-103	103	P-117	117	Q-112	112	P95-96	156	Q95-96	156
Vm-105	105	P-118	118	Q-116	116	P98-100	158	Q98-100	158

Vm-107	107			Q-117	117	P99-100	159	Q99-100	159
Vm-110	110			Q-118	118	P100-101	160	Q100-101	160
Vm-111	111					P101-102	162	Q101-102	162
Vm-112	112					P100-106	167	Q100-106	167
Vm-113	113					P105-108	171	Q105-108	171
Vm-114	114					P108-109	173	Q108-109	173
						P109-110	175	Q109-110	175
						P17-113	178	Q17-113	178
						P27-115	181	Q27-115	181
						P114-115	182	Q114-115	182
						P12-117	184	Q12-117	184
						P75-118	185	Q75-118	185
						P76-118	186	Q76-118	186
						P11-12	12	Q11-12	12
						P11-13	16	Q11-13	16
						P13-15	18	Q13-15	18
						P15-17	21	Q15-17	21
						P18-19	24	Q18-19	24
						P20-21	27	Q20-21	27
						P21-22	28	Q21-22	28
						P22-23	29	Q22-23	29
						P23-25	31	Q23-25	31
						P26-25	32	Q26-25	32
						P27-28	34	Q27-28	34
						P8-30	37	Q8-30	37
						P29-31	40	Q29-31	40
						P19-34	45	Q19-34	45
						P35-37	47	Q35-37	47
						P33-37	48	Q33-37	48
						P30-38	54	Q30-38	54
						P40-42	57	Q40-42	57
						P41-42	58	Q41-42	58
						P46-47	63	Q46-47	63
						P42-49	66	Q42-49	66
						P42-49	67	Q42-49	67
						P48-49	69	Q48-49	69
						P49-50	70	Q49-50	70
						P49-51	71	Q49-51	71
						P51-52	72	Q51-52	72
						P49-54	75	Q49-54	75
						P54-56	78	Q54-56	78
						P55-56	79	Q55-56	79
						P56-58	82	Q56-58	82
						P54-59	84	Q54-59	84
						P56-59	86	Q56-59	86
						P59-61	89	Q59-61	89
						P60-61	90	Q60-61	90

						P63-59	93	Q63-59	93
						P63-64	94	Q63-64	94
						P49-66	98	Q49-66	98
						P62-66	100	Q62-66	100
						P65-66	102	Q65-66	102
						P66-67	103	Q66-67	103
						P49-69	106	Q49-69	106
						P68-69	107	Q68-69	107
						P24-70	109	Q24-70	109
						P24-72	111	Q24-72	111
						P70-74	114	Q70-74	114
						P69-77	119	Q69-77	119
						P75-77	120	Q75-77	120
						P79-80	125	Q79-80	125
						P82-83	129	Q82-83	129
						P85-86	133	Q85-86	133
						P86-87	134	Q86-87	134
						P88-89	137	Q88-89	137
						P89-90	139	Q89-90	139
						P92-94	145	Q92-94	145
						P 94-96	150	Q94-96	150
						P80-98	152	Q80-98	152
						P94-100	155	Q94-100	155
						P96-97	157	Q96-97	157
						P100-103	163	Q100-103	163
						P104-105	168	Q104-105	168
						P105-105	169	Q105-105	169
						P106-107	172	Q106-107	172
						P108-109	173	Q108-109	173
						P32-113	179	Q32-113	179
						P32-114	180	Q32-114	180
						P68-116	183	Q68-116	183

APPENDIX B

DETAILED STATE ESTIMATION RESULTS

Detail simulation results under different scenarios are presented in the attached CD for future reference.

Detail simulation results under different scenarios are presented in the attached CD for future reference.

Detail simulation results for 14-, 30- and 118-bus systems, under different scenarios are presented below for future reference.

B.1 Detail Estimation Results of 14-Bus System

B.1.1 White Noise Mixed Measurements

Table B.1 IEEE 14-Bus System with white noise mixed SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	**V1**	1.0600	1.0591	1.0597	1.0591	1.0682	1.0615	1.0614
2	**V2**	1.0450	NA	1.0447	1.0439	1.0533	1.0465	1.0463
3	**V3**	1.0100	1.0079	1.0093	1.0083	1.0179	1.0113	1.0107
4	**V4**	1.0177	NA	1.0179	1.0169	1.0272	1.0191	1.0190
5	**V5**	1.0195	NA	1.0197	1.0187	1.0293	1.0209	1.0208
6	**V6**	1.0700	NA	1.0728	1.0733	1.0832	1.0728	1.0721
7	**V7**	1.0615	NA	1.0624	1.0620	1.0693	1.0632	1.0634
8	**V8**	1.0900	NA	1.0906	1.0910	1.0964	1.0914	1.0923
9	**V9**	1.0559	NA	1.0579	1.0579	1.0651	1.0584	1.0581
10	**V10**	1.0510	NA	1.0534	1.0533	1.0609	1.0537	1.0532
11	**V11**	1.0569	1.0602	1.0602	1.0602	1.0693	1.0602	1.0591
12	**V12**	1.0552	NA	1.0584	1.0597	1.0691	1.0583	1.0577
13	**V13**	1.0504	1.0550	1.0535	1.0550	1.0639	1.0534	1.0527
14	**V14**	1.0355	NA	1.0381	1.0396	1.0460	1.0382	1.0373
15	**P1**	2.3239	2.3412	2.3305	2.3412	2.3254	2.3318	2.3419
16	**P2**	0.1830	0.1863	0.1877	0.1863	0.1758	0.1865	0.1826

17	**P3**	-0.9420	-0.9606	-0.9519	-0.9606	-0.9488	-0.9515	-0.9603
18	**P4**	-0.4780	NA	-0.4737	-0.4713	-0.4463	-0.4782	-0.4730
19	**P5**	-0.0760	NA	-0.0793	-0.0792	-0.0658	-0.0770	-0.0808
20	**P6**	-0.1120	-0.1128	-0.1132	-0.1128	-0.1231	-0.1124	-0.1124
21	**P7**	0.0000	NA	0.0000	0.0000	-0.0105	-0.0003	-0.0003
22	**P8**	0.0000	NA	0.0000	0.0000	-0.0099	0.0000	0.0000
23	**P9**	-0.2950	-0.2980	-0.2979	-0.2980	-0.2858	-0.2972	-0.2946
24	**P10**	-0.0900	-0.0892	-0.0891	-0.0892	-0.0789	-0.0890	-0.0890
25	**P11**	-0.0350	NA	-0.0331	-0.0334	-0.0264	-0.0329	-0.0340
26	**P12**	-0.0610	-0.0601	-0.0611	-0.0617	-0.0704	-0.0610	-0.0600
27	**P13**	-0.1350	-0.1323	-0.1332	-0.1323	-0.1426	-0.1331	-0.1321
28	**P14**	-0.1490	NA	-0.1507	-0.1527	-0.1606	-0.1510	-0.1523
29	**Q1**	-0.1655	-0.1654	-0.1694	-0.1654	-0.1743	-0.1662	-0.1662
30	**Q2**	0.3086	0.3074	0.3057	0.3074	0.2961	0.3111	0.3126
31	**Q3**	0.0608	0.0600	0.0577	0.0600	0.0487	0.0618	0.0619
32	**Q4**	0.0390	NA	0.0407	0.0353	0.0517	0.0382	0.0367
33	**Q5**	-0.0160	NA	-0.0214	-0.0305	-0.0064	-0.0246	-0.0206
34	**Q6**	0.0523	0.0537	0.0568	0.0537	0.0630	0.0536	0.0536
35	**Q7**	0.0000	NA	-0.0064	-0.0102	-0.0158	-0.0056	-0.0025
36	**Q8**	0.1762	NA	0.1749	0.1793	0.1689	0.1747	0.1791
37	**Q9**	-0.1660	-0.1607	-0.1597	-0.1607	-0.1714	-0.1596	-0.1606
38	**Q10**	-0.0580	-0.0583	-0.0576	-0.0583	-0.0686	-0.0590	-0.0583
39	**Q11**	-0.0180	NA	-0.0115	-0.0131	-0.0131	-0.0131	-0.0181
40	**Q12**	-0.0160	-0.0159	-0.0139	-0.0107	-0.0059	-0.0147	-0.0145
41	**Q13**	-0.0580	-0.0575	-0.0550	-0.0470	-0.0473	-0.0575	-0.0576
42	**Q14**	-0.0500	NA	-0.0488	-0.0422	-0.0497	-0.0493	-0.0517
43	**P1-2**	1.5688	1.5436	1.5727	1.5809	1.5701	1.5743	1.5823
44	**P1-5**	0.7551	0.7568	0.7578	0.7603	0.7553	0.7575	0.7596
45	**P2-3**	0.7324	0.7196	0.7377	0.7426	0.7327	0.7380	0.7422
46	**P2-4**	0.5613	NA	0.5628	0.5637	0.5571	0.5632	0.5629
47	**P2-5**	0.4152	NA	0.4167	0.4172	0.4137	0.4164	0.4162
48	**P3-4**	-0.2329	-0.2341	-0.2378	-0.2419	-0.2391	-0.2370	-0.2419
49	**P4-5**	-0.6116	NA	-0.6115	-0.6132	-0.6019	-0.6144	-0.6137
50	**P4-7**	0.2807	0.2814	0.2810	0.2814	0.2907	0.2809	0.2803
51	**P4-9**	0.1608	NA	0.1610	0.1613	0.1628	0.1609	0.1605
52	**P5-6**	0.4409	NA	0.4416	0.4428	0.4605	0.4405	0.4393
53	**P6-11**	0.0735	0.0721	0.0731	0.0739	0.0635	0.0730	0.0734
54	**P6-12**	0.0779	NA	0.0779	0.0784	0.0861	0.0779	0.0772
55	**P6-13**	0.1775	0.1777	0.1773	0.1777	0.1878	0.1772	0.1764
56	**P7-8**	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000
57	**P7-9**	0.2807	NA	0.2810	0.2814	0.2704	0.2806	0.2800

58	**P9-10**	0.0523	NA	0.0498	0.0495	0.0425	0.0496	0.0504
59	**P9-14**	0.0943	0.0957	0.0944	0.0952	0.1049	0.0946	0.0955
60	**P10-11**	-0.0379	NA	-0.0394	-0.0398	-0.0365	-0.0395	-0.0387
61	**P12-13**	0.0161	0.0158	0.0162	0.0159	0.0149	0.0162	0.0165
62	**P13-14**	0.0564	0.0556	0.0580	0.0592	0.0577	0.0581	0.0586
63	**P2-1**	-1.5259	-1.5445	-1.5295	-1.5372	-1.5277	-1.5312	-1.5387
64	**P5-1**	-0.7275	NA	-0.7300	-0.7323	-0.7281	-0.7298	-0.7317
65	**P3-2**	-0.7091	-0.7199	-0.7141	-0.7187	-0.7098	-0.7145	-0.7184
66	**P4-2**	-0.5445	NA	-0.5459	-0.5468	-0.5408	-0.5464	-0.5461
67	**P5-2**	-0.4061	NA	-0.4076	-0.4081	-0.4049	-0.4073	-0.4072
68	**P4-3**	0.2366	NA	0.2417	0.2459	0.2429	0.2408	0.2459
69	**P5-4**	0.6167	0.6184	0.6167	0.6184	0.6068	0.6196	0.6188
70	**P7-4**	-0.2807	NA	-0.2810	-0.2814	-0.2907	-0.2809	-0.2803
71	**P9-4**	-0.1608	NA	-0.1610	-0.1613	-0.1628	-0.1609	-0.1605
72	**P6-5**	-0.4409	NA	-0.4416	-0.4428	-0.4605	-0.4405	-0.4393
73	**P11-6**	-0.0730	-0.0734	-0.0726	-0.0734	-0.0630	-0.0725	-0.0728
74	**P12-6**	-0.0771	NA	-0.0772	-0.0777	-0.0853	-0.0772	-0.0765
75	**P13-6**	-0.1754	NA	-0.1752	-0.1757	-0.1855	-0.1751	-0.1743
76	**P8-7**	0.0000	NA	0.0000	0.0000	-0.0099	0.0000	0.0000
77	**P9-7**	-0.2807	NA	-0.2810	-0.2814	-0.2704	-0.2806	-0.2800
78	**P10-9**	-0.0521	NA	-0.0497	-0.0494	-0.0424	-0.0495	-0.0503
79	**P14-9**	-0.0931	NA	-0.0932	-0.0941	-0.1035	-0.0935	-0.0943
80	**P11-10**	0.0380	NA	0.0395	0.0399	0.0366	0.0396	0.0388
81	**P13-12**	-0.0161	-0.0159	-0.0161	-0.0159	-0.0148	-0.0161	-0.0164
82	**P14-13**	-0.0559	NA	-0.0575	-0.0586	-0.0571	-0.0576	-0.0580
83	**Q1-2**	-0.2040	-0.2056	-0.2054	-0.2032	-0.2056	-0.2051	-0.2050
84	**Q1-5**	0.0385	0.0381	0.0360	0.0378	0.0313	0.0389	0.0388
85	**Q2-3**	0.0356	0.0349	0.0371	0.0378	0.0378	0.0363	0.0374
86	**Q2-4**	-0.0155	NA	-0.0188	-0.0181	-0.0213	-0.0156	-0.0160
87	**Q2-5**	0.0117	NA	0.0085	0.0094	0.0040	0.0122	0.0116
88	**Q3-4**	0.0447	0.0456	0.0416	0.0430	0.0370	0.0454	0.0453
89	**Q4-5**	0.1582	NA	0.1591	0.1602	0.1490	0.1606	0.1601
90	**Q4-7**	-0.0968	-0.0978	-0.0998	-0.1030	-0.0874	-0.0978	-0.0999
91	**Q4-9**	-0.0043	NA	-0.0075	-0.0093	-0.0030	-0.0062	-0.0060
92	**Q5-6**	0.1247	NA	0.1135	0.1068	0.1151	0.1189	0.1212
93	**Q6-11**	0.0356	0.0353	0.0333	0.0354	0.0456	0.0333	0.0354
94	**Q6-12**	0.0250	NA	0.0234	0.0197	0.0191	0.0242	0.0241
95	**Q6-13**	0.0722	0.0728	0.0698	0.0616	0.0669	0.0713	0.0717
96	**Q7-8**	-0.1716	-0.1657	-0.1704	-0.1746	-0.1647	-0.1702	-0.1744
97	**Q7-9**	0.0578	NA	0.0469	0.0440	0.0441	0.0497	0.0550
98	**Q9-10**	0.0422	NA	0.0375	0.0378	0.0378	0.0405	0.0428

99	**Q9-14**	0.0361	0.0372	0.0338	0.0277	0.0271	0.0353	0.0374
100	**Q10-11**	-0.0162	NA	-0.0203	-0.0207	-0.0311	-0.0188	-0.0158
101	**Q12-13**	0.0075	0.0075	0.0080	0.0075	0.0115	0.0080	0.0081
102	**Q13-14**	0.0175	0.0181	0.0186	0.0181	0.0266	0.0176	0.0181
103	**Q2-1**	0.2768	0.2823	0.2789	0.2783	0.2756	0.2782	0.2795
104	**Q5-1**	0.0223	NA	0.0256	0.0249	0.0268	0.0222	0.0229
105	**Q3-2**	0.0160	0.0160	0.0161	0.0169	0.0117	0.0165	0.0166
106	**Q4-2**	0.0302	NA	0.0338	0.0334	0.0338	0.0304	0.0307
107	**Q5-2**	-0.0210	NA	-0.0176	-0.0183	-0.0146	-0.0215	-0.0209
108	**Q4-3**	-0.0484	NA	-0.0449	-0.0459	-0.0407	-0.0487	-0.0483
109	**Q5-4**	-0.1420	-0.1438	-0.1429	-0.1438	-0.1336	-0.1443	-0.1438
110	**Q7-4**	0.1138	NA	0.1170	0.1204	0.1048	0.1149	0.1170
111	**Q9-4**	0.0173	NA	0.0206	0.0225	0.0162	0.0192	0.0190
112	**Q6-5**	-0.0805	NA	-0.0697	-0.0630	-0.0686	-0.0752	-0.0776
113	**Q11-6**	-0.0344	-0.0342	-0.0322	-0.0342	-0.0446	-0.0322	-0.0342
114	**Q12-6**	-0.0235	NA	-0.0219	-0.0183	-0.0174	-0.0227	-0.0226
115	**Q13-6**	-0.0680	NA	-0.0657	-0.0576	-0.0625	-0.0672	-0.0676
116	**Q8-7**	0.1762	0.1793	0.1749	0.1793	0.1689	0.1747	0.1791
117	**Q9-7**	-0.0498	NA	-0.0390	-0.0361	-0.0369	-0.0418	-0.0470
118	**Q10-9**	-0.0418	NA	-0.0372	-0.0376	-0.0375	-0.0402	-0.0425
119	**Q14-9**	-0.0336	NA	-0.0314	-0.0253	-0.0243	-0.0328	-0.0348
120	**Q11-10**	0.0164	NA	0.0207	0.0211	0.0315	0.0191	0.0161
121	**Q13-12**	-0.0075	-0.0076	-0.0079	-0.0075	-0.0115	-0.0079	-0.0080
122	**Q14-13**	-0.0164	NA	-0.0174	-0.0169	-0.0254	-0.0165	-0.0169

B.1.2 Presence of a Single Bad-data

Table B.2 IEEE 14-Bus System with a single bad-data (Q_1) in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	**V1**	1.0600	1.0591	1.0653	1.0591	1.0691	1.0616	1.0614
2	**V2**	1.0450	NA	1.0447	1.0439	1.0540	1.0465	1.0463
3	**V3**	1.0100	1.0079	1.0060	1.0082	1.0179	1.0113	1.0108
4	**V4**	1.0177	NA	1.0099	1.0168	1.0257	1.0191	1.0190
5	**V5**	1.0195	NA	1.0111	1.0186	1.0267	1.0209	1.0208
6	**V6**	1.0700	NA	1.0699	1.0733	1.0713	1.0728	1.0721
7	**V7**	1.0615	NA	1.0552	1.0620	1.0491	1.0632	1.0634
8	**V8**	1.0900	NA	1.0836	1.0910	1.0783	1.0914	1.0923
9	**V9**	1.0559	NA	1.0525	1.0579	1.0498	1.0584	1.0582
10	**V10**	1.0510	NA	1.0493	1.0533	1.0475	1.0537	1.0532
11	**V11**	1.0569	1.0602	1.0587	1.0602	1.0572	1.0602	1.0591

12	**V12**	1.0552	NA	1.0565	1.0598	1.0553	1.0583	1.0577
13	**V13**	1.0504	1.0550	1.0512	1.0550	1.0496	1.0534	1.0527
14	**V14**	1.0355	NA	1.0349	1.0396	1.0288	1.0382	1.0373
15	**P1**	2.3239	2.3412	2.3294	2.3412	2.3257	2.3324	2.3425
16	**P2**	0.1830	0.1863	0.1890	0.1863	0.1756	0.1862	0.1823
17	**P3**	-0.9420	-0.9606	-0.9497	-0.9606	-0.9594	-0.9515	-0.9602
18	**P4**	-0.4780	NA	-0.4801	-0.4713	-0.4439	-0.4783	-0.4731
19	**P5**	-0.0760	NA	-0.0753	-0.0792	-0.0983	-0.0773	-0.0810
20	**P6**	-0.1120	-0.1128	-0.1137	-0.1128	-0.1019	-0.1124	-0.1124
21	**P7**	0.0000	NA	0.0000	0.0000	0.0103	-0.0003	-0.0003
22	**P8**	0.0000	NA	0.0000	0.0000	-0.0597	0.0000	0.0000
23	**P9**	-0.2950	-0.2980	-0.2982	-0.2980	-0.2872	-0.2972	-0.2946
24	**P10**	-0.0900	-0.0892	-0.0893	-0.0892	-0.0791	-0.0890	-0.0890
25	**P11**	-0.0350	NA	-0.0312	-0.0334	-0.0014	-0.0329	-0.0340
26	**P12**	-0.0610	-0.0601	-0.0614	-0.0617	-0.0500	-0.0610	-0.0600
27	**P13**	-0.1350	-0.1323	-0.1330	-0.1323	-0.1323	-0.1331	-0.1321
28	**P14**	-0.1490	NA	-0.1512	-0.1527	-0.1654	-0.1510	-0.1523
29	**Q1**	-0.1655	0.1654	-0.0047	-0.1647	-0.1543	-0.1654	-0.1652
30	**Q2**	0.3086	0.3074	0.3186	0.3074	0.3297	0.3113	0.3117
31	**Q3**	0.0608	0.0600	0.0684	0.0600	0.0590	0.0616	0.0619
32	**Q4**	0.0390	NA	-0.0257	0.0346	0.1724	0.0373	0.0368
33	**Q5**	-0.0160	NA	-0.1785	-0.0313	-0.0328	-0.0243	-0.0207
34	**Q6**	0.0523	0.0537	0.0659	0.0537	0.0535	0.0536	0.0536
35	**Q7**	0.0000	NA	-0.0196	-0.0098	-0.1683	-0.0057	-0.0024
36	**Q8**	0.1762	NA	0.1749	0.1793	0.1795	0.1747	0.1791
37	**Q9**	-0.1660	-0.1607	-0.1576	-0.1607	-0.1506	-0.1596	-0.1606
38	**Q10**	-0.0580	-0.0583	-0.0561	-0.0583	-0.0483	-0.0590	-0.0583
39	**Q11**	-0.0180	NA	0.0095	-0.0131	-0.0169	-0.0130	-0.0181
40	**Q12**	-0.0160	-0.0159	-0.0077	-0.0106	-0.0260	-0.0147	-0.0145
41	**Q13**	-0.0580	-0.0575	-0.0488	-0.0468	-0.0576	-0.0575	-0.0576
42	**Q14**	-0.0500	NA	-0.0423	-0.0421	-0.0609	-0.0493	-0.0517
43	**P1-2**	1.5688	1.5436	1.5765	1.5809	1.5735	1.5748	1.5827
44	**P1-5**	0.7551	0.7568	0.7529	0.7603	0.7522	0.7577	0.7598
45	**P2-3**	0.7324	0.7196	0.7399	0.7426	0.7385	0.7380	0.7422
46	**P2-4**	0.5613	NA	0.5651	0.5637	0.5562	0.5633	0.5629
47	**P2-5**	0.4152	NA	0.4180	0.4172	0.4120	0.4164	0.4163
48	**P3-4**	-0.2329	-0.2341	-0.2336	-0.2419	-0.2441	-0.2369	-0.2418
49	**P4-5**	-0.6116	NA	-0.6096	-0.6132	-0.6021	-0.6144	-0.6137
50	**P4-7**	0.2807	0.2814	0.2796	0.2814	0.2912	0.2808	0.2803
51	**P4-9**	0.1608	NA	0.1603	0.1613	0.1587	0.1609	0.1605
52	**P5-6**	0.4409	NA	0.4435	0.4428	0.4230	0.4405	0.4392

53	**P6-11**	0.0735	0.0721	0.0732	0.0739	0.0638	0.0730	0.0734
54	**P6-12**	0.0779	NA	0.0786	0.0784	0.0734	0.0779	0.0772
55	**P6-13**	0.1775	0.1777	0.1779	0.1777	0.1839	0.1772	0.1763
56	**P7-8**	0.0000	NA	0.0000	0.0000	0.0597	0.0000	0.0000
57	**P7-9**	0.2807	NA	0.2796	0.2814	0.2418	0.2805	0.2800
58	**P9-10**	0.0523	NA	0.0481	0.0495	0.0176	0.0496	0.0504
59	**P9-14**	0.0943	0.0957	0.0936	0.0952	0.0957	0.0946	0.0955
60	**P10-11**	-0.0379	NA	-0.0413	-0.0398	-0.0615	-0.0395	-0.0387
61	**P12-13**	0.0161	0.0158	0.0166	0.0159	0.0227	0.0162	0.0165
62	**P13-14**	0.0564	0.0556	0.0593	0.0592	0.0718	0.0581	0.0586
63	**P2-1**	-1.5259	-1.5445	-1.5340	-1.5372	-1.5311	-1.5316	-1.5391
64	**P5-1**	-0.7275	NA	-0.7251	-0.7322	-0.7252	-0.7299	-0.7319
65	**P3-2**	-0.7091	-0.7199	-0.7161	-0.7187	-0.7153	-0.7145	-0.7184
66	**P4-2**	-0.5445	NA	-0.5480	-0.5468	-0.5400	-0.5465	-0.5461
67	**P5-2**	-0.4061	NA	-0.4085	-0.4081	-0.4032	-0.4074	-0.4072
68	**P4-3**	0.2366	NA	0.2376	0.2459	0.2482	0.2408	0.2459
69	**P5-4**	0.6167	0.6184	0.6149	0.6184	0.6070	0.6195	0.6188
70	**P7-4**	-0.2807	NA	-0.2796	-0.2814	-0.2912	-0.2808	-0.2803
71	**P9-4**	-0.1608	NA	-0.1603	-0.1613	-0.1587	-0.1609	-0.1605
72	**P6-5**	-0.4409	NA	-0.4435	-0.4428	-0.4230	-0.4405	-0.4392
73	**P11-6**	-0.0730	-0.0734	-0.0727	-0.0734	-0.0633	-0.0725	-0.0728
74	**P12-6**	-0.0771	NA	-0.0779	-0.0777	-0.0727	-0.0772	-0.0765
75	**P13-6**	-0.1754	NA	-0.1759	-0.1757	-0.1815	-0.1751	-0.1742
76	**P8-7**	0.0000	NA	0.0000	0.0000	-0.0597	0.0000	0.0000
77	**P9-7**	-0.2807	NA	-0.2796	-0.2814	-0.2418	-0.2805	-0.2800
78	**P10-9**	-0.0521	NA	-0.0480	-0.0494	-0.0176	-0.0495	-0.0503
79	**P14-9**	-0.0931	NA	-0.0925	-0.0941	-0.0945	-0.0935	-0.0943
80	**P11-10**	0.0380	NA	0.0415	0.0399	0.0619	0.0396	0.0388
81	**P13-12**	-0.0161	-0.0159	-0.0165	-0.0159	-0.0226	-0.0161	-0.0164
82	**P14-13**	-0.0559	NA	-0.0587	-0.0586	-0.0709	-0.0576	-0.0580
83	**Q1-2**	-0.2040	-0.2056	-0.1075	-0.2027	-0.2024	-0.2046	-0.2042
84	**Q1-5**	0.0385	0.0381	0.1028	0.0381	0.0481	0.0392	0.0390
85	**Q2-3**	0.0356	0.0349	0.0540	0.0379	0.0408	0.0365	0.0374
86	**Q2-4**	-0.0155	NA	0.0270	-0.0179	-0.0079	-0.0153	-0.0160
87	**Q2-5**	0.0117	NA	0.0590	0.0096	0.0242	0.0123	0.0116
88	**Q3-4**	0.0447	0.0456	0.0681	0.0431	0.0488	0.0454	0.0453
89	**Q4-5**	0.1582	NA	0.1732	0.1602	0.1748	0.1600	0.1601
90	**Q4-7**	-0.0968	-0.0978	-0.1041	-0.1033	0.0064	-0.0978	-0.0999
91	**Q4-9**	-0.0043	NA	-0.0129	-0.0095	0.0229	-0.0062	-0.0060
92	**Q5-6**	0.1247	NA	0.0859	0.1065	0.1516	0.1190	0.1212
93	**Q6-11**	0.0356	0.0353	0.0256	0.0354	0.0453	0.0333	0.0354

94	**Q6-12**	0.0250	NA	0.0187	0.0196	0.0322	0.0242	0.0241
95	**Q6-13**	0.0722	0.0728	0.0639	0.0614	0.0857	0.0713	0.0717
96	**Q7-8**	-0.1716	-0.1657	-0.1703	-0.1746	-0.1741	-0.1702	-0.1743
97	**Q7-9**	0.0578	NA	0.0292	0.0440	-0.0040	0.0496	0.0550
98	**Q9-10**	0.0422	NA	0.0227	0.0378	0.0218	0.0404	0.0428
99	**Q9-14**	0.0361	0.0372	0.0254	0.0276	0.0373	0.0352	0.0374
100	**Q10-11**	-0.0162	NA	-0.0336	-0.0207	-0.0266	-0.0189	-0.0158
101	**Q12-13**	0.0075	0.0075	0.0095	0.0075	0.0047	0.0080	0.0081
102	**Q13-14**	0.0175	0.0181	0.0205	0.0181	0.0281	0.0176	0.0181
103	**Q2-1**	0.2768	0.2823	0.1786	0.2778	0.2726	0.2778	0.2787
104	**Q5-1**	0.0223	NA	-0.0411	0.0246	0.0094	0.0220	0.0228
105	**Q3-2**	0.0160	0.0160	0.0003	0.0168	0.0101	0.0162	0.0166
106	**Q4-2**	0.0302	NA	-0.0110	0.0332	0.0202	0.0301	0.0308
107	**Q5-2**	-0.0210	NA	-0.0667	-0.0185	-0.0348	-0.0216	-0.0209
108	**Q4-3**	-0.0484	NA	-0.0710	-0.0460	-0.0519	-0.0487	-0.0483
109	**Q5-4**	-0.1420	-0.1438	-0.1566	-0.1438	-0.1590	-0.1437	-0.1438
110	**Q7-4**	0.1138	NA	0.1215	0.1207	0.0097	0.1149	0.1170
111	**Q9-4**	0.0173	NA	0.0261	0.0226	-0.0101	0.0193	0.0190
112	**Q6-5**	-0.0805	NA	-0.0422	-0.0627	-0.1097	-0.0752	-0.0776
113	**Q11-6**	-0.0344	-0.0342	-0.0246	-0.0342	-0.0443	-0.0322	-0.0342
114	**Q12-6**	-0.0235	NA	-0.0172	-0.0182	-0.0307	-0.0227	-0.0226
115	**Q13-6**	-0.0680	NA	-0.0598	-0.0574	-0.0811	-0.0672	-0.0676
116	**Q8-7**	0.1762	0.1793	0.1749	0.1793	0.1795	0.1747	0.1791
117	**Q9-7**	-0.0498	NA	-0.0214	-0.0361	0.0098	-0.0417	-0.0470
118	**Q10-9**	-0.0418	NA	-0.0225	-0.0376	-0.0217	-0.0401	-0.0425
119	**Q14-9**	-0.0336	NA	-0.0231	-0.0252	-0.0347	-0.0328	-0.0348
120	**Q11-10**	0.0164	NA	0.0341	0.0211	0.0273	0.0192	0.0161
121	**Q13-12**	-0.0075	-0.0076	-0.0095	-0.0075	-0.0046	-0.0079	-0.0080
122	**Q14-13**	-0.0164	NA	-0.0192	-0.0169	-0.0262	-0.0165	-0.0169

B.1.3 Presence of a Multiple Non-interacting Bad-data

Table B.3 IEEE 14-Bus System with five multiple non-interacting bad-data in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	**V1**	1.0600	1.0591	1.0700	1.0591	1.0681	1.0616	1.0625
2	**V2**	1.0450	NA	1.0499	1.0439	1.0530	1.0465	1.0472
3	**V3**	1.0100	1.0079	1.0071	1.0079	1.0163	1.0112	1.0115
4	**V4**	1.0177	NA	1.0232	1.0170	1.0271	1.0190	1.0200
5	**V5**	1.0195	NA	1.0256	1.0188	1.0292	1.0209	1.0218
6	**V6**	1.0700	NA	1.0919	1.0733	1.0857	1.0728	1.0732

7	**V7**	1.0615	NA	1.0707	1.0620	1.0732	1.0631	1.0644
8	**V8**	1.0900	NA	1.0987	1.0910	1.1002	1.0913	1.0933
9	**V9**	1.0559	NA	1.0711	1.0579	1.0700	1.0584	1.0592
10	**V10**	1.0510	NA	1.0680	1.0533	1.0652	1.0537	1.0543
11	**V11**	1.0569	1.0602	1.0769	1.0602	1.0702	1.0602	1.0602
12	**V12**	1.0552	NA	1.0820	1.0597	1.0739	1.0583	1.0587
13	**V13**	1.0504	1.1050	1.0765	1.0550	1.0681	1.0534	1.0538
14	**V14**	1.0355	NA	1.0600	1.0395	1.0532	1.0382	1.0384
15	**P1**	2.3239	2.3412	2.3320	2.3412	2.3299	2.3346	2.3446
16	**P2**	0.1830	0.1863	0.1864	0.1863	0.1748	0.1857	0.1818
17	**P3**	-0.9420	-0.9606	-0.9535	-0.9606	-0.9499	-0.9519	-0.9606
18	**P4**	-0.4780	NA	-0.4767	-0.4711	-0.4581	-0.4782	-0.4731
19	**P5**	-0.0760	NA	-0.0762	-0.0794	-0.1060	-0.0770	-0.0811
20	**P6**	-0.1120	-0.1128	-0.1146	-0.1128	-0.1024	-0.1126	-0.1125
21	**P7**	0.0000	NA	0.0000	0.0000	-0.0072	-0.0001	-0.0001
22	**P8**	0.0000	NA	0.0000	0.0000	-0.0099	0.0000	0.0000
23	**P9**	-0.2950	-0.2980	-0.2984	-0.2980	-0.2869	-0.2977	-0.2952
24	**P10**	-0.0900	-0.0892	-0.0894	-0.0892	-0.0995	-0.0891	-0.0891
25	**P11**	-0.0350	NA	-0.0343	-0.0334	-0.0341	-0.0330	-0.0341
26	**P12**	-0.0610	-0.0601	-0.0612	-0.0617	-0.0500	-0.0611	-0.0601
27	**P13**	-0.1350	-0.1323	-0.1309	-0.1323	-0.1221	-0.1332	-0.1323
28	**P14**	-0.1490	NA	-0.1504	-0.1527	-0.1471	-0.1513	-0.1525
29	**Q1**	-0.1655	-0.1654	-0.0571	-0.1654	-0.1713	-0.1650	-0.1636
30	**Q2**	0.3086	0.3074	0.2433	0.3074	0.2985	0.3114	0.3111
31	**Q3**	0.0608	-0.0600	-0.0255	0.0559	0.0334	0.0619	0.0588
32	**Q4**	0.0390	NA	0.0401	0.0390	0.0308	0.0363	0.0384
33	**Q5**	-0.0160	NA	-0.0810	-0.0290	-0.0191	-0.0236	-0.0210
34	**Q6**	0.0523	0.0537	0.0754	0.0537	0.0635	0.0539	0.0539
35	**Q7**	0.0000	NA	-0.0385	-0.0107	-0.0057	-0.0063	-0.0034
36	**Q8**	0.1762	NA	0.1748	0.1793	0.1691	0.1748	0.1792
37	**Q9**	-0.1660	-0.1607	-0.1523	-0.1607	-0.1508	-0.1596	-0.1606
38	**Q10**	-0.0580	-0.0583	-0.0524	-0.0583	-0.0482	-0.0590	-0.0583
39	**Q11**	-0.0180	NA	-0.0127	-0.0131	-0.0361	-0.0128	-0.0179
40	**Q12**	-0.0160	-0.0159	0.0073	-0.0109	-0.0060	-0.0147	-0.0148
41	**Q13**	-0.0580	-0.0575	-0.0265	-0.0473	-0.0535	-0.0575	-0.0575
42	**Q14**	-0.0500	NA	-0.0200	-0.0423	-0.0393	-0.0490	-0.0516
43	**P1-2**	1.5688	1.5436	1.5726	1.5808	1.5730	1.5763	1.5842
44	**P1-5**	0.7551	0.7568	0.7595	0.7604	0.7569	0.7583	0.7605
45	**P2-3**	0.7324	0.7196	0.7343	0.7424	0.7327	0.7384	0.7424
46	**P2-4**	0.5613	NA	0.5644	0.5638	0.5580	0.5636	0.5634
47	**P2-5**	0.4152	NA	0.4183	0.4173	0.4146	0.4167	0.4166

48	**P3-4**	-0.2329	-0.2341	-0.2427	-0.2421	-0.2402	-0.2370	-0.2420
49	**P4-5**	-0.6116	NA	-0.6130	-0.6132	-0.6023	-0.6147	-0.6139
50	**P4-7**	0.2807	0.2814	0.2778	0.2814	0.2830	0.2812	0.2807
51	**P4-9**	0.1608	NA	0.1595	0.1613	0.1589	0.1611	0.1607
52	**P5-6**	0.4409	NA	0.4469	0.4428	0.4222	0.4412	0.4399
53	**P6-11**	0.0735	0.0721	0.0769	0.0739	0.0821	0.0732	0.0735
54	**P6-12**	0.0779	NA	0.0787	0.0783	0.0702	0.0780	0.0773
55	**P6-13**	0.1775	0.1777	0.1767	0.1777	0.1674	0.1775	0.1766
56	**P7-8**	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000
57	**P7-9**	0.2807	NA	0.2778	0.2814	0.2659	0.2811	0.2806
58	**P9-10**	0.0523	NA	0.0477	0.0495	0.0524	0.0498	0.0505
59	**P9-14**	0.0943	0.0957	0.0912	0.0952	0.0855	0.0948	0.0956
60	**P10-11**	-0.0379	NA	-0.0418	-0.0398	-0.0471	-0.0395	-0.0387
61	**P12-13**	0.0161	0.0158	0.0168	0.0159	0.0197	0.0162	0.0165
62	**P13-14**	0.0564	0.0556	0.0608	0.0592	0.0631	0.0582	0.0587
63	**P2-1**	-1.5259	-1.5445	-1.5306	-1.5371	-1.5305	-1.5331	-1.5406
64	**P5-1**	-0.7275	NA	-0.7319	-0.7324	-0.7296	-0.7305	-0.7326
65	**P3-2**	-0.7091	-0.7199	-0.7109	-0.7184	-0.7098	-0.7149	-0.7186
66	**P4-2**	-0.5445	NA	-0.5476	-0.5468	-0.5417	-0.5468	-0.5465
67	**P5-2**	-0.4061	NA	-0.4093	-0.4082	-0.4057	-0.4076	-0.4076
68	**P4-3**	0.2366	NA	0.2466	0.2462	0.2440	0.2409	0.2460
69	**P5-4**	0.6167	0.6184	0.6181	0.6184	0.6072	0.6199	0.6191
70	**P7-4**	-0.2807	NA	-0.2778	-0.2814	-0.2830	-0.2812	-0.2807
71	**P9-4**	-0.1608	NA	-0.1595	-0.1613	-0.1589	-0.1611	-0.1607
72	**P6-5**	-0.4409	NA	-0.4469	-0.4428	-0.4222	-0.4412	-0.4399
73	**P11-6**	-0.0730	-0.0734	-0.0763	-0.0734	-0.0814	-0.0726	-0.0729
74	**P12-6**	-0.0771	NA	-0.0781	-0.0777	-0.0697	-0.0773	-0.0766
75	**P13-6**	-0.1754	NA	-0.1749	-0.1757	-0.1656	-0.1754	-0.1746
76	**P8-7**	0.0000	NA	0.0000	0.0000	-0.0099	0.0000	0.0000
77	**P9-7**	-0.2807	NA	-0.2778	-0.2814	-0.2659	-0.2811	-0.2806
78	**P10-9**	-0.0521	NA	-0.0476	-0.0494	-0.0523	-0.0496	-0.0504
79	**P14-9**	-0.0931	NA	-0.0903	-0.0941	-0.0846	-0.0937	-0.0944
80	**P11-10**	0.0380	NA	0.0420	0.0399	0.0473	0.0396	0.0389
81	**P13-12**	-0.0161	-0.0159	-0.0167	-0.0159	-0.0196	-0.0161	-0.0164
82	**P14-13**	-0.0559	NA	-0.0601	-0.0586	-0.0625	-0.0577	-0.0581
83	**Q1-2**	-0.2040	0.2056	-0.1138	-0.2028	-0.2027	-0.2043	-0.2029
84	**Q1-5**	0.0385	0.0381	0.0567	0.0374	0.0314	0.0393	0.0393
85	**Q2-3**	0.0356	0.0349	0.0762	0.0395	0.0449	0.0365	0.0386
86	**Q2-4**	-0.0155	NA	-0.0197	-0.0187	-0.0224	-0.0151	-0.0162
87	**Q2-5**	0.0117	NA	0.0041	0.0088	0.0028	0.0123	0.0114
88	**Q3-4**	0.0447	0.0456	-0.0016	0.0406	0.0285	0.0456	0.0437

89	**Q4-5**	0.1582	NA	0.1448	0.1602	0.1486	0.1592	0.1601
90	**Q4-7**	-0.0968	-0.0978	-0.1148	-0.1026	-0.1078	-0.0978	-0.0998
91	**Q4-9**	-0.0043	NA	-0.0224	-0.0092	-0.0130	-0.0063	-0.0061
92	**Q5-6**	0.1247	NA	0.0585	0.1072	0.1002	0.1187	0.1211
93	**Q6-11**	0.0356	0.0353	0.0460	0.0354	0.0454	0.0333	0.0353
94	**Q6-12**	0.0250	NA	0.0051	0.0199	0.0167	0.0242	0.0242
95	**Q6-13**	0.0722	0.0728	0.0406	0.0619	0.0628	0.0713	0.0718
96	**Q7-8**	-0.1716	-0.1657	-0.1704	-0.1746	-0.1649	-0.1703	-0.1745
97	**Q7-9**	0.0578	NA	-0.0002	0.0440	0.0340	0.0492	0.0542
98	**Q9-10**	0.0422	NA	0.0211	0.0379	0.0411	0.0402	0.0426
99	**Q9-14**	0.0361	0.0372	0.0017	0.0278	0.0272	0.0350	0.0372
100	**Q10-11**	-0.0162	NA	-0.0315	-0.0207	-0.0075	-0.0191	-0.0160
101	**Q12-13**	0.0075	0.0075	0.0111	0.0075	0.0096	0.0080	0.0080
102	**Q13-14**	0.0175	0.0181	0.0215	0.0181	0.0152	0.0176	0.0181
103	**Q2-1**	0.2768	0.2823	0.1826	0.2778	0.2732	0.2777	0.2773
104	**Q5-1**	0.0223	NA	0.0030	0.0253	0.0272	0.0220	0.0224
105	**Q3-2**	0.0160	0.0160	-0.0239	0.0152	0.0049	0.0163	0.0151
106	**Q4-2**	0.0302	NA	0.0341	0.0340	0.0351	0.0300	0.0309
107	**Q5-2**	-0.0210	NA	-0.0137	-0.0177	-0.0133	-0.0215	-0.0208
108	**Q4-3**	-0.0484	NA	-0.0017	-0.0435	-0.0321	-0.0489	-0.0467
109	**Q5-4**	-0.1420	-0.1438	-0.1288	-0.1438	-0.1333	-0.1429	-0.1438
110	**Q7-4**	0.1138	NA	0.1321	0.1199	0.1252	0.1148	0.1169
111	**Q9-4**	0.0173	NA	0.0353	0.0224	0.0256	0.0193	0.0190
112	**Q6-5**	-0.0805	NA	-0.0162	-0.0634	-0.0613	-0.0749	-0.0775
113	**Q11-6**	-0.0344	-0.0342	-0.0446	-0.0342	-0.0439	-0.0322	-0.0342
114	**Q12-6**	-0.0235	NA	-0.0037	-0.0184	-0.0156	-0.0227	-0.0228
115	**Q13-6**	-0.0680	NA	-0.0370	-0.0579	-0.0593	-0.0672	-0.0677
116	**Q8-7**	0.1762	0.1793	0.1748	0.1793	0.1691	0.1748	0.1792
117	**Q9-7**	-0.0498	NA	0.0076	-0.0361	-0.0271	-0.0413	-0.0463
118	**Q10-9**	-0.0418	NA	-0.0209	-0.0376	-0.0407	-0.0399	-0.0423
119	**Q14-9**	-0.0336	NA	0.0002	-0.0254	-0.0253	-0.0325	-0.0347
120	**Q11-10**	0.0164	NA	0.0320	0.0210	0.0078	0.0194	0.0163
121	**Q13-12**	-0.0075	-0.0076	-0.0110	-0.0075	-0.0095	-0.0079	-0.0079
122	**Q14-13**	-0.0164	NA	-0.0202	-0.0169	-0.0140	-0.0165	-0.0169

B.1.4 Presence of a Multiple Interacting Bad-data

Table B.4 IEEE 14-Bus System with five multiple interacting bad-data in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	**V1**	1.0600	1.0091	1.0507	1.0585	1.0691	1.0616	1.0618

2	**V2**	1.0450	NA	1.0287	1.0433	1.0535	1.0464	1.0465
3	**V3**	1.0100	1.0079	0.9859	1.0079	1.0168	1.0112	1.0107
4	**V4**	1.0177	NA	1.0017	1.0162	1.0273	1.0190	1.0192
5	**V5**	1.0195	NA	1.0043	1.0180	1.0286	1.0209	1.0210
6	**V6**	1.0700	NA	1.0674	1.0733	1.0709	1.0728	1.0722
7	**V7**	1.0615	NA	1.0479	1.0621	1.0695	1.0631	1.0633
8	**V8**	1.0900	NA	1.0765	1.0910	1.0967	1.0913	1.0922
9	**V9**	1.0559	NA	1.0472	1.0578	1.0608	1.0584	1.0581
10	**V10**	1.0510	NA	1.0452	1.0533	1.0536	1.0537	1.0532
11	**V11**	1.0569	1.0602	1.0574	1.0602	1.0566	1.0602	1.0592
12	**V12**	1.0552	NA	1.0548	1.0598	1.0535	1.0582	1.0576
13	**V13**	1.0504	1.0550	1.0492	1.0550	1.0497	1.0534	1.0527
14	**V14**	1.0355	NA	1.0317	1.0396	1.0363	1.0382	1.0373
15	**P1**	2.3239	2.3412	2.3248	2.3412	2.3294	2.3336	2.3449
16	**P2**	0.1830	0.1863	0.1890	0.1863	0.1748	0.1856	0.1818
17	**P3**	-0.9420	-0.9606	-0.9515	-0.9606	-0.9498	-0.9519	-0.9598
18	**P4**	-0.4780	NA	-0.4735	-0.4714	-0.4429	-0.4773	-0.4715
19	**P5**	-0.0760	NA	-0.0734	-0.0790	-0.0690	-0.0760	-0.0834
20	**P6**	-0.1120	-0.1128	-0.1142	-0.1128	-0.1227	-0.1126	-0.1125
21	**P7**	0.0000	NA	0.0000	0.0000	-0.0103	-0.0001	-0.0001
22	**P8**	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000
23	**P9**	-0.2950	-0.2980	-0.2985	-0.2980	-0.2872	-0.2977	-0.2953
24	**P10**	-0.0900	-0.0892	-0.0895	-0.0892	-0.0994	-0.0891	-0.0891
25	**P11**	-0.0350	NA	-0.0294	-0.0334	-0.0313	-0.0330	-0.0342
26	**P12**	-0.0610	-0.0601	-0.0617	-0.0617	-0.0702	-0.0613	-0.0601
27	**P13**	-0.1350	-0.1323	-0.1328	-0.1323	-0.1422	-0.1332	-0.1323
28	**P14**	-0.1490	NA	-0.1517	-0.1527	-0.1564	-0.1521	-0.1525
29	**Q1**	-0.1655	-0.1654	-0.0168	-0.1654	-0.1557	-0.1635	-0.1636
30	**Q2**	0.3086	0.3074	0.2160	0.3074	0.2982	0.3091	0.3113
31	**Q3**	0.0608	-0.0600	-0.0135	0.0635	0.0349	0.0616	0.0585
32	**Q4**	0.0390	NA	0.0461	0.0282	0.0874	0.0369	0.0415
33	**Q5**	-0.0160	NA	-0.0699	-0.0341	0.0108	-0.0234	-0.0195
34	**Q6**	0.0523	0.0537	0.0731	0.0560	0.0435	0.0539	0.0539
35	**Q7**	0.0000	NA	-0.0334	-0.0055	0.0291	-0.0061	-0.0059
36	**Q8**	0.1762	NA	0.1749	0.1793	0.1690	0.1748	0.1792
37	**Q9**	-0.1660	-0.1607	-0.1556	-0.1607	-0.1708	-0.1596	-0.1606
38	**Q10**	-0.0580	-0.0583	-0.0547	-0.0583	-0.0684	-0.0590	-0.0583
39	**Q11**	-0.0180	NA	0.0302	-0.0129	-0.0420	-0.0128	-0.0177
40	**Q12**	-0.0160	-0.0159	-0.0028	-0.0105	-0.0259	-0.0147	-0.0157
41	**Q13**	-0.0580	-0.0575	-0.0434	-0.0466	-0.0676	-0.0575	-0.0575
42	**Q14**	-0.0500	NA	-0.0367	-0.0420	-0.0582	-0.0490	-0.0516

43	**P1-2**	1.5688	1.5436	1.5676	1.5810	1.5734	1.5757	1.5841
44	**P1-5**	0.7551	0.7568	0.7571	0.7602	0.7560	0.7579	0.7608
45	**P2-3**	0.7324	0.7196	0.7335	0.7428	0.7330	0.7383	0.7419
46	**P2-4**	0.5613	NA	0.5629	0.5637	0.5583	0.5634	0.5633
47	**P2-5**	0.4152	NA	0.4170	0.4171	0.4144	0.4164	0.4170
48	**P3-4**	-0.2329	-0.2341	-0.2423	-0.2418	-0.2398	-0.2372	-0.2416
49	**P4-5**	-0.6116	NA	-0.6120	-0.6132	-0.6024	-0.6147	-0.6122
50	**P4-7**	0.2807	0.2814	0.2782	0.2814	0.2913	0.2815	0.2807
51	**P4-9**	0.1608	NA	0.1596	0.1612	0.1666	0.1613	0.1608
52	**P5-6**	0.4409	NA	0.4455	0.4428	0.4580	0.4416	0.4399
53	**P6-11**	0.0735	0.0721	0.0733	0.0739	0.0667	0.0732	0.0735
54	**P6-12**	0.0779	NA	0.0793	0.0784	0.0839	0.0782	0.0772
55	**P6-13**	0.1775	0.1777	0.1787	0.1777	0.1848	0.1777	0.1767
56	**P7-8**	0.0000	NA	0.0000	0.0000	-0.0099	0.0000	0.0000
57	**P7-9**	0.2807	NA	0.2782	0.2814	0.2910	0.2815	0.2807
58	**P9-10**	0.0523	NA	0.0465	0.0495	0.0649	0.0498	0.0506
59	**P9-14**	0.0943	0.0957	0.0928	0.0951	0.1054	0.0953	0.0956
60	**P10-11**	-0.0379	NA	-0.0431	-0.0398	-0.0348	-0.0395	-0.0387
61	**P12-13**	0.0161	0.0158	0.0169	0.0159	0.0128	0.0162	0.0164
62	**P13-14**	0.0564	0.0556	0.0606	0.0592	0.0530	0.0585	0.0586
63	**P2-1**	-1.5259	-1.5445	-1.5245	-1.5373	-1.5309	-1.5325	-1.5405
64	**P5-1**	-0.7275	NA	-0.7286	-0.7321	-0.7288	-0.7302	-0.7328
65	**P3-2**	-0.7091	-0.7199	-0.7092	-0.7188	-0.7100	-0.7147	-0.7181
66	**P4-2**	-0.5445	NA	-0.5455	-0.5467	-0.5420	-0.5465	-0.5465
67	**P5-2**	-0.4061	NA	-0.4076	-0.4080	-0.4056	-0.4074	-0.4079
68	**P4-3**	0.2366	NA	0.2463	0.2458	0.2436	0.2410	0.2456
69	**P5-4**	0.6167	0.6184	0.6173	0.6184	0.6074	0.6199	0.6174
70	**P7-4**	-0.2807	NA	-0.2782	-0.2814	-0.2913	-0.2815	-0.2807
71	**P9-4**	-0.1608	NA	-0.1596	-0.1612	-0.1666	-0.1613	-0.1608
72	**P6-5**	-0.4409	NA	-0.4455	-0.4428	-0.4580	-0.4416	-0.4399
73	**P11-6**	-0.0730	-0.0734	-0.0728	-0.0734	-0.0662	-0.0726	-0.0730
74	**P12-6**	-0.0771	NA	-0.0786	-0.0777	-0.0830	-0.0775	-0.0765
75	**P13-6**	-0.1754	NA	-0.1766	-0.1757	-0.1824	-0.1756	-0.1746
76	**P8-7**	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000
77	**P9-7**	-0.2807	NA	-0.2782	-0.2814	-0.2910	-0.2815	-0.2807
78	**P10-9**	-0.0521	NA	-0.0464	-0.0494	-0.0646	-0.0497	-0.0505
79	**P14-9**	-0.0931	NA	-0.0918	-0.0940	-0.1039	-0.0942	-0.0945
80	**P11-10**	0.0380	NA	0.0434	0.0400	0.0349	0.0396	0.0388
81	**P13-12**	-0.0161	-0.0159	-0.0168	-0.0159	-0.0128	-0.0161	-0.0163
82	**P14-13**	-0.0559	NA	-0.0599	-0.0586	-0.0525	-0.0579	-0.0580
83	**Q1-2**	-0.2040	-0.2056	-0.0823	-0.2035	-0.1946	-0.2029	-0.2029

84	**Q1-5**	0.0385	0.0381	0.0655	0.0381	0.0389	0.0394	0.0393
85	**Q2-3**	0.0356	0.0349	0.0744	0.0365	0.0448	0.0365	0.0388
86	**Q2-4**	-0.0155	NA	-0.0190	-0.0177	-0.0208	-0.0155	-0.0163
87	**Q2-5**	0.0117	NA	0.0035	0.0098	0.0096	0.0119	0.0113
88	**Q3-4**	0.0447	0.0456	0.0029	0.0450	0.0300	0.0453	0.0434
89	**Q4-5**	0.1582	NA	0.1412	0.1602	0.1697	0.1592	0.1600
90	**Q4-7**	-0.0968	-0.0978	-0.1083	-0.1066	-0.0879	-0.0978	-0.0978
91	**Q4-9**	-0.0043	NA	-0.0184	-0.0106	0.0057	-0.0062	-0.0054
92	**Q5-6**	0.1247	NA	0.0653	0.1037	0.1656	0.1188	0.1221
93	**Q6-11**	0.0356	0.0353	0.0193	0.0353	0.0453	0.0333	0.0353
94	**Q6-12**	0.0250	NA	0.0151	0.0195	0.0332	0.0242	0.0248
95	**Q6-13**	0.0722	0.0728	0.0599	0.0612	0.0815	0.0713	0.0721
96	**Q7-8**	-0.1716	-0.1657	-0.1703	-0.1746	-0.1648	-0.1703	-0.1745
97	**Q7-9**	0.0578	NA	0.0108	0.0449	0.0885	0.0493	0.0538
98	**Q9-10**	0.0422	NA	0.0070	0.0377	0.0671	0.0402	0.0424
99	**Q9-14**	0.0361	0.0372	0.0170	0.0274	0.0475	0.0351	0.0372
100	**Q10-11**	-0.0162	NA	-0.0478	-0.0208	-0.0019	-0.0190	-0.0162
101	**Q12-13**	0.0075	0.0075	0.0109	0.0075	0.0055	0.0080	0.0076
102	**Q13-14**	0.0175	0.0181	0.0232	0.0181	0.0148	0.0176	0.0181
103	**Q2-1**	0.2768	-0.2823	0.1571	0.2788	0.2646	0.2762	0.2775
104	**Q5-1**	0.0223	NA	0.0001	0.0248	0.0194	0.0219	0.0227
105	**Q3-2**	0.0160	0.0160	-0.0164	0.0185	0.0049	0.0163	0.0151
106	**Q4-2**	0.0302	NA	0.0367	0.0331	0.0335	0.0303	0.0311
107	**Q5-2**	-0.0210	NA	-0.0106	-0.0187	-0.0200	-0.0212	-0.0206
108	**Q4-3**	-0.0484	NA	-0.0052	-0.0478	-0.0337	-0.0486	-0.0464
109	**Q5-4**	-0.1420	-0.1438	-0.1247	-0.1438	-0.1541	-0.1429	-0.1438
110	**Q7-4**	0.1138	NA	0.1261	0.1242	0.1054	0.1149	0.1148
111	**Q9-4**	0.0173	NA	0.0318	0.0238	0.0081	0.0193	0.0184
112	**Q6-5**	-0.0805	NA	-0.0212	-0.0600	-0.1165	-0.0749	-0.0783
113	**Q11-6**	-0.0344	-0.0342	-0.0183	-0.0341	-0.0441	-0.0322	-0.0342
114	**Q12-6**	-0.0235	NA	-0.0137	-0.0180	-0.0314	-0.0227	-0.0233
115	**Q13-6**	-0.0680	NA	-0.0558	-0.0572	-0.0769	-0.0672	-0.0680
116	**Q8-7**	0.1762	0.1793	0.1749	0.1793	0.1690	0.1748	0.1792
117	**Q9-7**	-0.0498	NA	-0.0030	-0.0370	-0.0796	-0.0414	-0.0459
118	**Q10-9**	-0.0418	NA	-0.0069	-0.0374	-0.0665	-0.0399	-0.0421
119	**Q14-9**	-0.0336	NA	-0.0148	-0.0251	-0.0443	-0.0326	-0.0347
120	**Q11-10**	0.0164	NA	0.0485	0.0212	0.0021	0.0194	0.0165
121	**Q13-12**	-0.0075	-0.0076	-0.0108	-0.0075	-0.0055	-0.0079	-0.0076
122	**Q14-13**	-0.0164	NA	-0.0219	-0.0169	-0.0139	-0.0165	-0.0169

B.2 Detail Estimation Results of 30-Bus System

B.2.1 White Noise Mixed Measurements

Table B.5 IEEE 30 Bus System with white noise mixed SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	Vm-1	1.0600	1.0600	1.0599	1.0608	1.0576	1.0601	1.0608
2	Vm-2	1.0450	NA	1.0452	1.0460	1.0430	1.0453	1.0457
3	Vm-3	1.0212	1.0212	1.0213	1.0221	1.0198	1.0213	1.0221
4	Vm-4	1.0123	1.0133	1.0124	1.0133	1.0107	1.0125	1.0134
5	Vm-5	1.0100	1.0176	1.0105	1.0112	1.0076	1.0099	1.0110
6	Vm-6	1.0106	NA	1.0106	1.0117	1.0086	1.0104	1.0117
7	Vm-7	1.0026	NA	1.0027	1.0037	1.0005	1.0024	1.0036
8	Vm-8	1.0100	1.0010	1.0098	1.0112	1.0078	1.0096	1.0111
9	Vm-9	1.0511	NA	1.0527	1.0529	1.0495	1.0519	1.0525
10	Vm-10	1.0454	1.0491	1.0476	1.0479	1.0447	1.0468	1.0469
11	Vm-11	1.0820	NA	1.0833	1.0828	1.0776	1.0825	1.0824
12	Vm-12	1.0573	1.0557	1.0576	1.0577	1.0559	1.0578	1.0582
13	Vm-13	1.0710	NA	1.0711	1.0712	1.0708	1.0713	1.0718
14	Vm-14	1.0425	NA	1.0431	1.0431	1.0403	1.0433	1.0435
15	Vm-15	1.0379	NA	1.0388	1.0387	1.0355	1.0388	1.0390
16	Vm-16	1.0446	NA	1.0457	1.0461	1.0439	1.0454	1.0458
17	Vm-17	1.0402	NA	1.0424	1.0427	1.0389	1.0416	1.0416
18	Vm-18	1.0284	1.0294	1.0298	1.0294	1.0282	1.0295	1.0296
19	Vm-19	1.0259	NA	1.0275	1.0270	1.0251	1.0271	1.0271
20	Vm-20	1.0300	NA	1.0317	1.0312	1.0283	1.0313	1.0312
21	Vm-21	1.0330	1.0431	1.0357	1.0363	1.0331	1.0349	1.0347
22	Vm-22	1.0335	NA	1.0363	1.0370	1.0338	1.0355	1.0353
23	Vm-23	1.0274	NA	1.0290	1.0307	1.0228	1.0291	1.0287
24	Vm-24	1.0218	1.0252	1.0235	1.0252	1.0208	1.0235	1.0234
25	Vm-25	1.0176	1.0098	1.0153	1.0098	1.0198	1.0169	1.0187
26	Vm-26	0.9999	1.0022	1.0009	1.0022	0.9959	1.0022	1.0015
27	Vm-27	1.0235	NA	1.0219	1.0225	1.0241	1.0225	1.0247
28	Vm-28	1.0071	1.0052	1.0059	1.0052	1.0043	1.0064	1.0075
29	Vm-29	1.0037	1.0042	1.0039	1.0042	0.9956	1.0042	1.0042
30	Vm-30	0.9922	NA	0.9917	0.9921	0.9837	0.9921	0.9927
31	P-1	2.6096	2.6103	2.5988	2.5958	2.6034	2.6022	2.6134
32	P-2	0.1830	0.1822	0.1867	0.1822	0.1911	0.1827	0.1676
33	P-3	-0.0240	NA	-0.0292	-0.0328	-0.0462	-0.0298	-0.0360
34	P-4	-0.0760	-0.0751	-0.0690	-0.0751	-0.0649	-0.0750	-0.0621

35	P-5	-0.9420	-0.9366	-0.9365	-0.9382	-0.9268	-0.9368	-0.9384
36	P-6	0.0000	NA	-0.0055	0.0138	-0.0577	0.0033	0.0058
37	P-7	-0.2280	-0.2306	-0.2322	-0.2306	-0.2327	-0.2306	-0.2306
38	P-8	-0.3000	NA	-0.2970	-0.2959	-0.2961	-0.2960	-0.2960
39	P-9	0.0000	NA	0.0000	0.0000	-0.0021	0.0001	0.0000
40	P-10	-0.0580	-0.0571	-0.0569	-0.0571	-0.0471	-0.0572	-0.0607
41	P-11	0.0000	NA	0.0000	0.0000	-0.0100	0.0000	0.0000
42	P-12	-0.1120	NA	-0.1175	-0.1168	-0.1274	-0.1170	-0.1142
43	P-13	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000
44	P-14	-0.0620	-0.0613	-0.0619	-0.0613	-0.0514	-0.0614	-0.0621
45	P-15	-0.0820	-0.0813	-0.0807	-0.0813	-0.0714	-0.0814	-0.0813
46	P-16	-0.0350	-0.0349	-0.0357	-0.0349	-0.0448	-0.0349	-0.0366
47	P-17	-0.0900	NA	-0.0882	-0.0887	-0.0728	-0.0888	-0.0889
48	P-18	-0.0320	-0.0322	-0.0317	-0.0322	-0.0221	-0.0322	-0.0328
49	P-19	-0.0950	-0.0944	-0.0949	-0.0944	-0.0966	-0.0949	-0.0959
50	P-20	-0.0220	NA	-0.0220	-0.0224	-0.0385	-0.0216	-0.0215
51	P-21	-0.1750	-0.1780	-0.1767	-0.1777	-0.1680	-0.1761	-0.1748
52	P-22	0.0000	NA	0.0031	-0.0005	-0.0151	0.0003	0.0009
53	P-23	-0.0320	NA	-0.0315	-0.0312	-0.0504	-0.0313	-0.0320
54	P-24	-0.0870	-0.0856	-0.0848	-0.0856	-0.0756	-0.0856	-0.0856
55	P-25	0.0000	NA	-0.0043	-0.0014	0.0056	-0.0018	-0.0036
56	P-26	-0.0350	NA	-0.0340	-0.0354	-0.0449	-0.0353	-0.0335
57	P-27	0.0000	NA	-0.0004	0.0012	0.0154	0.0010	-0.0009
58	P-28	0.0000	NA	0.0064	0.0033	0.0628	0.0013	0.0064
59	P-29	-0.0240	-0.0236	-0.0239	-0.0236	-0.0337	-0.0236	-0.0252
60	P-30	-0.1060	-0.1057	-0.1062	-0.1057	-0.1157	-0.1057	-0.1069
61	Q-1	-0.2042	-0.2064	-0.2082	-0.2064	-0.2156	-0.2057	-0.2041
62	Q-2	0.4337	0.4435	0.4365	0.4340	0.4371	0.4403	0.4306
63	Q-3	-0.0120	NA	-0.0083	-0.0108	0.0074	-0.0126	-0.0107
64	Q-4	-0.0160	-0.0154	-0.0163	-0.0154	-0.0154	-0.0048	-0.0151
65	Q-5	0.1666	0.1659	0.1689	0.1659	0.1561	0.1634	0.1663
66	Q-6	0.0000	NA	0.0038	0.0408	0.0199	-0.0125	0.0099
67	Q-7	-0.1090	-0.1109	-0.1089	-0.1088	-0.1041	-0.1085	-0.1095
68	Q-8	0.0611	NA	0.0611	0.0784	0.0587	0.0576	0.0634
69	Q-9	0.0000	NA	0.0032	0.0000	0.0077	0.0001	0.0044
70	Q-10	-0.0200	-0.0207	-0.0191	-0.0207	-0.0156	-0.0206	-0.0208
71	Q-11	0.1606	NA	0.1593	0.1559	0.1454	0.1593	0.1559
72	Q-12	-0.0750	NA	-0.0821	-0.0855	-0.0720	-0.0786	-0.0776
73	Q-13	0.1045	NA	0.1036	0.1036	0.1138	0.1036	0.1036
74	Q-14	-0.0160	-0.0163	-0.0154	-0.0163	-0.0261	-0.0153	-0.0159
75	Q-15	-0.0250	-0.0255	-0.0259	-0.0345	-0.0354	-0.0255	-0.0255
76	Q-16	-0.0180	-0.0180	-0.0201	-0.0180	-0.0080	-0.0201	-0.0180

77	Q-17	-0.0580	NA	-0.0522	-0.0534	-0.0735	-0.0555	-0.0573
78	Q-18	-0.0090	-0.0087	-0.0086	-0.0087	0.0012	-0.0087	-0.0086
79	Q-19	-0.0340	-0.0348	-0.0341	-0.0348	-0.0248	-0.0348	-0.0337
80	Q-20	-0.0070	NA	-0.0077	-0.0126	-0.0175	-0.0067	-0.0081
81	Q-21	-0.1120	-0.1106	-0.1076	-0.1106	-0.1101	-0.1076	-0.1094
82	Q-22	0.0000	NA	0.0117	0.0169	0.0268	0.0080	0.0025
83	Q-23	-0.0160	NA	-0.0129	-0.0041	-0.0315	-0.0129	-0.0160
84	Q-24	-0.0670	-0.0666	-0.0621	-0.0342	-0.0766	-0.0623	-0.0666
85	Q-25	0.0000	NA	-0.0221	-0.0930	0.0302	-0.0128	-0.0010
86	Q-26	-0.0230	NA	-0.0149	0.0040	-0.0324	-0.0149	-0.0227
87	Q-27	0.0000	NA	-0.0039	0.0301	0.0258	-0.0080	0.0037
88	Q-28	0.0000	NA	-0.0239	-0.0700	-0.0403	-0.0089	-0.0168
89	Q-29	-0.0090	NA	-0.0031	-0.0040	-0.0233	-0.0039	-0.0098
90	Q-30	-0.0190	-0.0190	-0.0185	-0.0190	-0.0289	-0.0190	-0.0196
91	P 1-2	1.7331	NA	1.7245	1.7224	1.7224	1.7269	1.7366
92	P 1-3	0.8765	0.8707	0.8743	0.8734	0.8810	0.8753	0.8767
93	P 2-4	0.4365	0.4395	0.4356	0.4345	0.4391	0.4360	0.4327
94	P 3-4	0.8214	NA	0.8142	0.8097	0.8033	0.8145	0.8096
95	P 2-5	0.8236	0.8199	0.8213	0.8199	0.8169	0.8203	0.8201
96	P 2-6	0.6038	NA	0.6026	0.5989	0.6057	0.6016	0.5992
97	P 4-6	0.7213	0.7291	0.7201	0.7092	0.7191	0.7147	0.7181
98	P 5-7	-0.1478	-0.1474	-0.1445	-0.1474	-0.1390	-0.1456	-0.1474
99	P 6-7	0.3813	0.3870	0.3822	0.3835	0.3770	0.3817	0.3835
100	P 6-8	0.2956	0.2917	0.2919	0.2917	0.2816	0.2917	0.2917
101	P 6-9	0.2772	0.2717	0.2777	0.2796	0.2817	0.2779	0.2792
102	P 6-10	0.1584	0.1596	0.1586	0.1598	0.1587	0.1588	0.1596
103	P 9-11	0.0000	NA	0.0000	0.0000	0.0100	0.0000	0.0000
104	P 9-10	0.2772	NA	0.2777	0.2796	0.2696	0.2780	0.2793
105	P 4-12	0.4419	NA	0.4421	0.4416	0.4398	0.4422	0.4438
106	P 12-13	0.0000	NA	0.0000	0.0000	-0.0099	0.0000	0.0000
107	P 12-14	0.0786	0.0800	0.0777	0.0775	0.0717	0.0776	0.0785
108	P 12-15	0.1789	NA	0.1761	0.1765	0.1757	0.1767	0.1785
109	P 12-16	0.0724	0.0727	0.0709	0.0707	0.0749	0.0709	0.0727
110	P 14-15	0.0158	0.0156	0.0151	0.0154	0.0196	0.0155	0.0156
111	P 16-17	0.0369	NA	0.0346	0.0353	0.0295	0.0355	0.0356
112	P 15-18	0.0602	0.0593	0.0590	0.0593	0.0606	0.0594	0.0606
113	P 18-19	0.0278	0.0281	0.0269	0.0268	0.0381	0.0269	0.0274
114	P 19-20	-0.0673	NA	-0.0681	-0.0676	-0.0586	-0.0681	-0.0685
115	P 10-20	0.0903	NA	0.0911	0.0911	0.0982	0.0906	0.0910
116	P 10-17	0.0533	0.0536	0.0537	0.0536	0.0435	0.0536	0.0536
117	P 10-21	0.1579	NA	0.1584	0.1604	0.1605	0.1588	0.1575
118	P 10-22	0.0762	NA	0.0762	0.0773	0.0790	0.0766	0.0760

119	P 21-22	-0.0183	NA	-0.0194	-0.0184	-0.0085	-0.0184	-0.0184
120	P 15-23	0.0504	NA	0.0493	0.0492	0.0611	0.0493	0.0500
121	P 22-24	0.0574	0.0580	0.0594	0.0580	0.0548	0.0580	0.0580
122	P 23-24	0.0180	0.0179	0.0175	0.0177	0.0102	0.0177	0.0177
123	P 24-25	-0.0121	-0.0118	-0.0084	-0.0104	-0.0110	-0.0104	-0.0104
124	P 25-26	0.0354	0.0357	0.0344	0.0357	0.0457	0.0357	0.0339
125	P 25-27	-0.0476	-0.0480	-0.0473	-0.0480	-0.0511	-0.0480	-0.0480
126	P 28-27	0.1807	0.1793	0.1809	0.1793	0.1893	0.1794	0.1842
127	P 27-29	0.0619	NA	0.0619	0.0615	0.0733	0.0615	0.0631
128	P 27-30	0.0709	0.0722	0.0710	0.0706	0.0800	0.0706	0.0718
129	P 29-30	0.0370	0.0371	0.0372	0.0371	0.0383	0.0371	0.0371
130	P 8-28	-0.0054	NA	-0.0061	-0.0053	-0.0154	-0.0054	-0.0054
131	P 6-28	0.1867	NA	0.1812	0.1820	0.1423	0.1840	0.1838
132	P 2-1	-1.6809	-1.6536	-1.6728	-1.6710	-1.6706	-1.6751	-1.6844
133	P 3-1	-0.8454	NA	-0.8434	-0.8426	-0.8495	-0.8443	-0.8457
134	P 4-2	-0.4263	NA	-0.4255	-0.4244	-0.4288	-0.4258	-0.4227
135	P 4-3	-0.8129	-0.8014	-0.8058	-0.8014	-0.7951	-0.8061	-0.8013
136	P 5-2	-0.7942	NA	-0.7920	-0.7907	-0.7878	-0.7911	-0.7909
137	P 6-2	-0.5843	-0.5796	-0.5832	-0.5798	-0.5861	-0.5823	-0.5801
138	P 6-4	-0.7150	NA	-0.7138	-0.7031	-0.7128	-0.7085	-0.7119
139	P 7-5	0.1495	NA	0.1462	0.1491	0.1405	0.1473	0.1491
140	P 7-6	-0.3775	NA	-0.3784	-0.3797	-0.3732	-0.3779	-0.3797
141	P 8-6	-0.2946	NA	-0.2909	-0.2906	-0.2807	-0.2906	-0.2906
142	P 9-6	-0.2772	NA	-0.2777	-0.2796	-0.2817	-0.2779	-0.2792
143	P 10-6	-0.1584	NA	-0.1586	-0.1598	-0.1587	-0.1588	-0.1596
144	P 11-9	0.0000	NA	0.0000	0.0000	-0.0100	0.0000	0.0000
145	P 10-9	-0.2772	-0.2796	-0.2777	-0.2796	-0.2696	-0.2780	-0.2793
146	P 12-4	-0.4419	-0.4497	-0.4421	-0.4416	-0.4398	-0.4422	-0.4438
147	P 13-12	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000
148	P 14-12	-0.0778	NA	-0.0770	-0.0768	-0.0710	-0.0769	-0.0777
149	P 15-12	-0.1767	-0.1733	-0.1740	-0.1744	-0.1735	-0.1746	-0.1763
150	P 16-12	-0.0719	NA	-0.0704	-0.0702	-0.0743	-0.0704	-0.0721
151	P 15-14	-0.0158	NA	-0.0150	-0.0154	-0.0195	-0.0155	-0.0156
152	P 17-16	-0.0368	NA	-0.0346	-0.0353	-0.0294	-0.0354	-0.0355
153	P 18-15	-0.0598	NA	-0.0586	-0.0589	-0.0602	-0.0591	-0.0602
154	P 19-18	-0.0277	NA	-0.0268	-0.0267	-0.0380	-0.0269	-0.0274
155	P 20-19	0.0674	0.0687	0.0683	0.0678	0.0587	0.0683	0.0687
156	P 20-10	-0.0894	-0.0902	-0.0902	-0.0902	-0.0972	-0.0898	-0.0902
157	P 17-10	-0.0532	NA	-0.0536	-0.0534	-0.0434	-0.0534	-0.0534
158	P 21-10	-0.1567	-0.1564	-0.1573	-0.1593	-0.1594	-0.1577	-0.1564
159	P 22-10	-0.0757	NA	-0.0757	-0.0768	-0.0784	-0.0761	-0.0755
160	P 22-21	0.0183	0.0184	0.0194	0.0184	0.0086	0.0184	0.0184

161	P 23-15	-0.0500	-0.0507	-0.0490	-0.0489	-0.0607	-0.0490	-0.0497
162	P 24-22	-0.0569	-0.0568	-0.0589	-0.0575	-0.0543	-0.0575	-0.0575
163	P 24-23	-0.0180	-0.0177	-0.0175	-0.0177	-0.0102	-0.0177	-0.0177
164	P 25-24	0.0122	NA	0.0086	0.0110	0.0111	0.0106	0.0105
165	P 26-25	-0.0350	NA	-0.0340	-0.0354	-0.0449	-0.0353	-0.0335
166	P 27-25	0.0479	NA	0.0475	0.0484	0.0514	0.0483	0.0483
167	P 27-28	-0.1807	-0.1842	-0.1809	-0.1793	-0.1893	-0.1794	-0.1842
168	P 29-27	-0.0610	NA	-0.0611	-0.0607	-0.0720	-0.0607	-0.0622
169	P 30-27	-0.0693	NA	-0.0694	-0.0690	-0.0778	-0.0690	-0.0702
170	P 30-29	-0.0367	-0.0367	-0.0369	-0.0367	-0.0379	-0.0367	-0.0367
171	P 28-8	0.0055	0.0054	0.0061	0.0054	0.0155	0.0054	0.0054
172	P 28-6	-0.1862	NA	-0.1806	-0.1814	-0.1420	-0.1835	-0.1832
173	Q 1-2	-0.2470	NA	-0.2499	-0.2487	-0.2517	-0.2486	-0.2463
174	Q 1-3	0.0428	0.0421	0.0418	0.0424	0.0361	0.0429	0.0421
175	Q 2-4	0.0475	0.0481	0.0482	0.0481	0.0446	0.0480	0.0466
176	Q 3-4	-0.0385	NA	-0.0354	-0.0368	-0.0276	-0.0387	-0.0377
177	Q 2-5	0.0278	0.0268	0.0267	0.0274	0.0304	0.0300	0.0268
178	Q 2-6	0.0137	NA	0.0155	0.0144	0.0136	0.0172	0.0129
179	Q 4-6	-0.1591	-0.1583	-0.1545	-0.1583	-0.1483	-0.1464	-0.1582
180	Q 5-7	0.1149	0.1149	0.1168	0.1153	0.1083	0.1149	0.1149
181	Q 6-7	-0.0278	-0.0284	-0.0298	-0.0284	-0.0266	-0.0284	-0.0273
182	Q 6-8	-0.0720	-0.0736	-0.0671	-0.0736	-0.0636	-0.0671	-0.0711
183	Q 6-9	-0.0809	-0.0822	-0.0890	-0.0839	-0.0829	-0.0859	-0.0821
184	Q 6-10	0.0019	NA	-0.0024	-0.0007	-0.0008	-0.0012	0.0012
185	Q 9-11	-0.1560	-0.1516	-0.1548	-0.1516	-0.1416	-0.1548	-0.1516
186	Q 9-10	0.0588	NA	0.0526	0.0511	0.0495	0.0526	0.0573
187	Q 4-12	0.1441	NA	0.1436	0.1473	0.1424	0.1435	0.1454
188	Q 12-13	-0.1032	-0.1023	-0.1023	-0.1023	-0.1122	-0.1023	-0.1023
189	Q 12-14	0.0240	0.0237	0.0229	0.0236	0.0305	0.0229	0.0237
190	Q 12-15	0.0679	NA	0.0642	0.0654	0.0771	0.0650	0.0670
191	Q 12-16	0.0335	0.0335	0.0298	0.0282	0.0284	0.0324	0.0322
192	Q 14-15	0.0065	0.0063	0.0060	0.0058	0.0030	0.0061	0.0063
193	Q 16-17	0.0144	NA	0.0087	0.0092	0.0192	0.0112	0.0130
194	Q 15-18	0.0160	0.0153	0.0142	0.0154	0.0055	0.0154	0.0153
195	Q 18-19	0.0062	0.0059	0.0048	0.0059	0.0059	0.0059	0.0059
196	Q 19-20	-0.0279	NA	-0.0294	-0.0290	-0.0190	-0.0290	-0.0279
197	Q 10-20	0.0371	NA	0.0394	0.0438	0.0389	0.0379	0.0382
198	Q 10-17	0.0443	0.0449	0.0441	0.0449	0.0549	0.0449	0.0449
199	Q 10-21	0.1001	NA	0.0931	0.0894	0.0880	0.0931	0.0973
200	Q 10-22	0.0460	NA	0.0421	0.0392	0.0383	0.0421	0.0446
201	Q 21-22	-0.0143	NA	-0.0168	-0.0235	-0.0245	-0.0168	-0.0145
202	Q 15-23	0.0291	NA	0.0260	0.0171	0.0350	0.0260	0.0282

203	Q 22-24	0.0306	0.0295	0.0360	0.0315	0.0396	0.0323	0.0315
204	Q 23-24	0.0124	0.0125	0.0125	0.0125	0.0026	0.0125	0.0116
205	Q 24-25	0.0201	0.0196	0.0305	0.0541	0.0096	0.0267	0.0207
206	Q 25-26	0.0237	0.0233	0.0154	-0.0035	0.0336	0.0154	0.0233
207	Q 25-27	-0.0037	-0.0038	-0.0073	-0.0363	0.0062	-0.0019	-0.0038
208	Q 28-27	0.0504	0.0519	0.0515	0.0478	0.0418	0.0512	0.0488
209	Q 27-29	0.0167	NA	0.0122	0.0130	0.0320	0.0130	0.0176
210	Q 27-30	0.0166	0.0173	0.0147	0.0152	0.0274	0.0152	0.0173
211	Q 29-30	0.0061	0.0060	0.0075	0.0075	0.0062	0.0075	0.0061
212	Q 8-28	-0.0054	NA	-0.0005	0.0103	0.0008	-0.0040	-0.0022
213	Q 6-27	0.0011	NA	0.0212	0.0531	0.0263	0.0095	0.0129
214	Q 2-1	0.3447	0.3363	0.3461	0.3442	0.3485	0.3451	0.3442
215	Q 3-1	0.0265	NA	0.0271	0.0260	0.0350	0.0262	0.0271
216	Q 4-2	-0.0554	NA	-0.0563	-0.0564	-0.0519	-0.0560	-0.0552
217	Q 4-3	0.0544	0.0525	0.0508	0.0519	0.0424	0.0542	0.0529
218	Q 5-2	0.0517	NA	0.0520	0.0507	0.0478	0.0485	0.0514
219	Q 6-2	0.0058	0.0060	0.0038	0.0040	0.0067	0.0019	0.0055
220	Q 6-4	0.1719	NA	0.1671	0.1703	0.1609	0.1587	0.1708
221	Q 7-5	-0.1313	NA	-0.1333	-0.1317	-0.1251	-0.1314	-0.1314
222	Q 7-6	0.0223	NA	0.0244	0.0229	0.0209	0.0229	0.0218
223	Q 8-6	0.0666	NA	0.0615	0.0681	0.0579	0.0615	0.0656
224	Q 9-6	0.0972	NA	0.1055	0.1005	0.0998	0.1024	0.0986
225	Q 10-6	0.0110	NA	0.0153	0.0137	0.0137	0.0141	0.0118
226	Q 11-9	0.1606	NA	0.1593	0.1559	0.1454	0.1593	0.1559
227	Q 10-9	-0.0508	-0.0521	-0.0446	-0.0431	-0.0420	-0.0446	-0.0493
228	Q 12-4	-0.0972	-0.1004	-0.0967	-0.1004	-0.0959	-0.0966	-0.0982
229	Q 13-12	0.1045	NA	0.1036	0.1036	0.1138	0.1036	0.1036
230	Q 14-12	-0.0225	NA	-0.0214	-0.0221	-0.0291	-0.0214	-0.0222
231	Q 15-12	-0.0636	-0.0629	-0.0601	-0.0613	-0.0728	-0.0608	-0.0628
232	Q 16-12	-0.0324	NA	-0.0288	-0.0272	-0.0273	-0.0313	-0.0310
233	Q 15-14	-0.0064	NA	-0.0060	-0.0057	-0.0030	-0.0061	-0.0063
234	Q 17-16	-0.0141	NA	-0.0085	-0.0089	-0.0190	-0.0110	-0.0128
235	Q 18-15	-0.0152	NA	-0.0135	-0.0147	-0.0047	-0.0147	-0.0146
236	Q 19-18	-0.0061	NA	-0.0047	-0.0058	-0.0058	-0.0058	-0.0058
237	Q 20-19	0.0283	0.0282	0.0298	0.0293	0.0193	0.0293	0.0282
238	Q 20-10	-0.0353	-0.0363	-0.0375	-0.0419	-0.0368	-0.0361	-0.0363
239	Q 17-10	-0.0439	NA	-0.0437	-0.0445	-0.0545	-0.0445	-0.0445
240	Q 21-10	-0.0977	-0.0957	-0.0908	-0.0871	-0.0857	-0.0908	-0.0949
241	Q 22-10	-0.0449	NA	-0.0411	-0.0382	-0.0373	-0.0411	-0.0435
242	Q 22-21	0.0143	0.0145	0.0168	0.0236	0.0245	0.0168	0.0145
243	Q 23-15	-0.0284	-0.0285	-0.0254	-0.0166	-0.0340	-0.0254	-0.0276
244	Q 24-22	-0.0299	-0.0308	-0.0352	-0.0308	-0.0388	-0.0316	-0.0308

245	Q 24-23	-0.0123	-0.0124	-0.0123	-0.0124	-0.0025	-0.0124	-0.0115
246	Q 25-24	-0.0200	NA	-0.0302	-0.0532	-0.0095	-0.0264	-0.0205
247	Q 26-25	-0.0230	NA	-0.0149	0.0040	-0.0324	-0.0149	-0.0227
248	Q 27-25	0.0042	NA	0.0078	0.0370	-0.0057	0.0023	0.0043
249	Q 27-28	-0.0375	-0.0379	-0.0385	-0.0351	-0.0280	-0.0385	-0.0355
250	Q 29-27	-0.0151	NA	-0.0106	-0.0115	-0.0295	-0.0114	-0.0159
251	Q 30-27	-0.0136	NA	-0.0116	-0.0122	-0.0233	-0.0122	-0.0141
252	Q 30-29	-0.0054	-0.0054	-0.0069	-0.0068	-0.0055	-0.0068	-0.0054
253	Q 28-8	-0.0380	-0.0395	-0.0429	-0.0536	-0.0440	-0.0394	-0.0413
254	Q 28-6	-0.0123	N/A	-0.0324	-0.0642	-0.0382	-0.0207	-0.0242

B.2.2 Presence of a Single Bad-data

Table B.6 IEEE 30 Bus System with a single bad-data (Q_14) in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	Vm-1	1.0600	1.0600	1.0599	1.0609	1.0576	1.0601	1.0609
2	Vm-2	1.0450	NA	1.0452	1.0462	1.0430	1.0454	1.0458
3	Vm-3	1.0212	1.0212	1.0213	1.0223	1.0198	1.0213	1.0222
4	Vm-4	1.0123	1.0133	1.0124	1.0133	1.0107	1.0126	1.0134
5	Vm-5	1.0100	1.0176	1.0105	1.0112	1.0076	1.0104	1.0111
6	Vm-6	1.0106	NA	1.0106	1.0117	1.0086	1.0108	1.0118
7	Vm-7	1.0026	NA	1.0027	1.0037	1.0005	1.0029	1.0036
8	Vm-8	1.0100	1.0010	1.0098	1.0112	1.0075	1.0101	1.0111
9	Vm-9	1.0511	NA	1.0527	1.0529	1.0499	1.0523	1.0525
10	Vm-10	1.0454	1.0491	1.0476	1.0479	1.0450	1.0471	1.0469
11	Vm-11	1.0820	NA	1.0833	1.0828	1.0819	1.0829	1.0825
12	Vm-12	1.0573	1.0557	1.0576	1.0559	1.0504	1.0577	1.0583
13	Vm-13	1.0710	NA	1.0711	1.0695	1.0653	1.0712	1.0718
14	Vm-14	1.0425	NA	1.0456	1.0442	1.0370	1.0437	1.0437
15	Vm-15	1.0379	NA	1.0392	1.0387	1.0302	1.0389	1.0390
16	Vm-16	1.0446	NA	1.0457	1.0452	1.0415	1.0455	1.0458
17	Vm-17	1.0402	NA	1.0424	1.0427	1.0412	1.0418	1.0417
18	Vm-18	1.0284	1.0294	1.0299	1.0294	1.0205	1.0296	1.0296
19	Vm-19	1.0259	NA	1.0275	1.0270	1.0204	1.0272	1.0272
20	Vm-20	1.0300	NA	1.0317	1.0312	1.0263	1.0314	1.0313
21	Vm-21	1.0330	1.0431	1.0357	1.0363	1.0331	1.0352	1.0347
22	Vm-22	1.0335	NA	1.0363	1.0370	1.0335	1.0358	1.0352
23	Vm-23	1.0274	NA	1.0290	1.0307	1.0209	1.0291	1.0286
24	Vm-24	1.0218	1.0252	1.0235	1.0252	1.0191	1.0235	1.0233
25	Vm-25	1.0176	1.0098	1.0153	1.0098	1.0142	1.0169	1.0187
26	Vm-26	0.9999	1.0022	1.0009	1.0022	0.9922	1.0022	1.0015

27	Vm-27	1.0235	NA	1.0219	1.0223	1.0213	1.0229	1.0247
28	Vm-28	1.0071	1.0052	1.0059	1.0052	1.0017	1.0069	1.0076
29	Vm-29	1.0037	1.0042	1.0039	1.0042	0.9958	1.0042	1.0042
30	Vm-30	0.9922	NA	0.9917	0.9921	0.9878	0.9923	0.9927
31	P-1	2.6096	2.6103	2.5988	2.5939	2.6034	2.6021	2.6133
32	P-2	0.1830	0.1822	0.1867	0.1822	0.1911	0.1827	0.1677
33	P-3	-0.0240	NA	-0.0292	-0.0319	-0.0462	-0.0303	-0.0361
34	P-4	-0.0760	-0.0751	-0.0689	-0.0751	-0.0648	-0.0750	-0.0621
35	P-5	-0.9420	-0.9366	-0.9365	-0.9382	-0.9268	-0.9367	-0.9384
36	P-6	0.0000	NA	-0.0056	0.0112	0.0180	0.0035	0.0061
37	P-7	-0.2280	-0.2306	-0.2322	-0.2306	-0.2327	-0.2306	-0.2306
38	P-8	-0.3000	NA	-0.2970	-0.2959	-0.2959	-0.2960	-0.2960
39	P-9	0.0000	NA	0.0000	0.0000	0.0100	0.0001	0.0000
40	P-10	-0.0580	-0.0571	-0.0569	-0.0571	-0.0192	-0.0572	-0.0609
41	P-11	0.0000	NA	0.0000	0.0000	-0.0100	0.0000	0.0000
42	P-12	-0.1120	NA	-0.1169	-0.1137	-0.1270	-0.1181	-0.1139
43	P-13	0.0000	NA	0.0000	0.0000	0.0096	0.0000	0.0000
44	P-14	-0.0620	-0.0613	-0.0620	-0.0613	-0.0711	-0.0614	-0.0625
45	P-15	-0.0820	-0.0813	-0.0809	-0.0813	-0.1058	-0.0814	-0.0813
46	P-16	-0.0350	-0.0349	-0.0358	-0.0349	-0.0251	-0.0349	-0.0366
47	P-17	-0.0900	NA	-0.0880	-0.0888	-0.0678	-0.0885	-0.0889
48	P-18	-0.0320	-0.0322	-0.0318	-0.0322	-0.0420	-0.0322	-0.0328
49	P-19	-0.0950	-0.0944	-0.0950	-0.0944	-0.0876	-0.0949	-0.0959
50	P-20	-0.0220	NA	-0.0220	-0.0224	-0.0215	-0.0219	-0.0215
51	P-21	-0.1750	-0.1780	-0.1767	-0.1777	-0.1680	-0.1757	-0.1748
52	P-22	0.0000	NA	0.0031	-0.0005	-0.0140	0.0005	0.0009
53	P-23	-0.0320	NA	-0.0317	-0.0307	-0.0328	-0.0306	-0.0320
54	P-24	-0.0870	-0.0856	-0.0848	-0.0856	-0.0767	-0.0856	-0.0856
55	P-25	0.0000	NA	-0.0043	-0.0016	0.0083	-0.0017	-0.0036
56	P-26	-0.0350	NA	-0.0340	-0.0354	-0.0450	-0.0353	-0.0335
57	P-27	0.0000	NA	-0.0004	0.0012	0.0033	0.0011	-0.0009
58	P-28	0.0000	NA	0.0065	0.0033	-0.0377	0.0012	0.0064
59	P-29	-0.0240	-0.0236	-0.0239	-0.0236	-0.0337	-0.0236	-0.0252
60	P-30	-0.1060	-0.1057	-0.1062	-0.1057	-0.1157	-0.1058	-0.1069
61	Q-1	-0.2042	-0.2064	-0.2082	-0.2064	-0.2156	-0.2081	-0.2041
62	Q-2	0.4337	0.4435	0.4366	0.4363	0.4371	0.4403	0.4304
63	Q-3	-0.0120	NA	-0.0083	-0.0048	0.0074	-0.0126	-0.0106
64	Q-4	-0.0160	-0.0154	-0.0163	-0.0154	0.0082	-0.0152	-0.0151
65	Q-5	0.1666	0.1659	0.1689	0.1659	0.1561	0.1648	0.1663
66	Q-6	0.0000	NA	0.0038	0.0393	0.0380	-0.0001	0.0099
67	Q-7	-0.1090	-0.1109	-0.1089	-0.1094	-0.1041	-0.1085	-0.1095
68	Q-8	0.0611	NA	0.0611	0.0782	0.0648	0.0575	0.0634

69	Q-9	0.0000	NA	0.0033	0.0000	-0.0098	0.0001	0.0044
70	Q-10	-0.0200	-0.0207	-0.0191	-0.0207	-0.0305	-0.0206	-0.0182
71	Q-11	0.1606	NA	0.1593	0.1559	0.1665	0.1593	0.1559
72	Q-12	-0.0750	NA	-0.0964	-0.1240	-0.1227	-0.0824	-0.0786
73	Q-13	0.1045	NA	0.1036	0.1036	0.1137	0.1036	0.1036
74	Q-14	-0.0160	0.0163	0.0046	0.0006	0.0062	-0.0120	-0.0140
75	Q-15	-0.0250	-0.0255	-0.0282	-0.0255	-0.0354	-0.0255	-0.0255
76	Q-16	-0.0180	-0.0180	-0.0202	-0.0180	-0.0282	-0.0201	-0.0180
77	Q-17	-0.0580	NA	-0.0521	-0.0486	-0.0249	-0.0547	-0.0573
78	Q-18	-0.0090	-0.0087	-0.0096	-0.0087	-0.0239	-0.0087	-0.0086
79	Q-19	-0.0340	-0.0348	-0.0344	-0.0348	-0.0447	-0.0348	-0.0337
80	Q-20	-0.0070	NA	-0.0081	-0.0126	0.0029	-0.0076	-0.0081
81	Q-21	-0.1120	-0.1106	-0.1076	-0.1106	-0.1006	-0.1076	-0.1111
82	Q-22	0.0000	NA	0.0118	0.0170	0.0158	0.0098	0.0016
83	Q-23	-0.0160	NA	-0.0152	-0.0041	-0.0242	-0.0137	-0.0171
84	Q-24	-0.0670	-0.0666	-0.0621	-0.0343	-0.0694	-0.0640	-0.0666
85	Q-25	0.0000	NA	-0.0221	-0.0921	-0.0019	-0.0151	-0.0008
86	Q-26	-0.0230	NA	-0.0149	0.0040	-0.0271	-0.0149	-0.0227
87	Q-27	0.0000	NA	-0.0038	0.0284	0.0270	-0.0042	0.0035
88	Q-28	0.0000	NA	-0.0239	-0.0690	-0.0659	-0.0089	-0.0166
89	Q-29	-0.0090	NA	-0.0031	-0.0035	-0.0249	-0.0055	-0.0098
90	Q-30	-0.0190	-0.0190	-0.0185	-0.0190	-0.0089	-0.0190	-0.0196
91	P 1-2	1.7331	NA	1.7245	1.7215	1.7224	1.7269	1.7366
92	P 1-3	0.8765	0.8707	0.8743	0.8724	0.8810	0.8752	0.8767
93	P 2-4	0.4365	0.4395	0.4356	0.4337	0.4391	0.4360	0.4327
94	P 3-4	0.8214	NA	0.8142	0.8097	0.8033	0.8140	0.8096
95	P 2-5	0.8236	0.8199	0.8213	0.8199	0.8169	0.8203	0.8201
96	P 2-6	0.6038	NA	0.6026	0.5988	0.6057	0.6015	0.5992
97	P 4-6	0.7213	0.7291	0.7201	0.7119	0.7191	0.7142	0.7180
98	P 5-7	-0.1478	-0.1474	-0.1445	-0.1474	-0.1390	-0.1456	-0.1474
99	P 6-7	0.3813	0.3870	0.3822	0.3836	0.3770	0.3817	0.3835
100	P 6-8	0.2956	0.2917	0.2919	0.2917	0.3017	0.2917	0.2917
101	P 6-9	0.2772	0.2717	0.2776	0.2796	0.2641	0.2777	0.2793
102	P 6-10	0.1584	0.1596	0.1586	0.1598	0.1510	0.1587	0.1596
103	P 9-11	0.0000	NA	0.0000	0.0000	0.0100	0.0000	0.0000
104	P 9-10	0.2772	NA	0.2776	0.2796	0.2641	0.2778	0.2794
105	P 4-12	0.4419	NA	0.4422	0.4381	0.4400	0.4422	0.4439
106	P 12-13	0.0000	NA	0.0000	0.0000	-0.0096	0.0000	0.0000
107	P 12-14	0.0786	0.0800	0.0794	0.0783	0.0873	0.0777	0.0789
108	P 12-15	0.1789	NA	0.1751	0.1753	0.1855	0.1759	0.1785
109	P 12-16	0.0724	0.0727	0.0707	0.0708	0.0497	0.0705	0.0727
110	P 14-15	0.0158	0.0156	0.0167	0.0162	0.0154	0.0156	0.0156

111	P 16-17	0.0369	NA	0.0345	0.0355	0.0244	0.0351	0.0355
112	P 15-18	0.0602	0.0593	0.0592	0.0593	0.0515	0.0594	0.0606
113	P 18-19	0.0278	0.0281	0.0270	0.0268	0.0092	0.0269	0.0274
114	P 19-20	-0.0673	NA	-0.0680	-0.0676	-0.0784	-0.0681	-0.0685
115	P 10-20	0.0903	NA	0.0910	0.0911	0.1012	0.0910	0.0910
116	P 10-17	0.0533	0.0536	0.0537	0.0536	0.0435	0.0536	0.0536
117	P 10-21	0.1579	NA	0.1584	0.1604	0.1676	0.1584	0.1575
118	P 10-22	0.0762	NA	0.0762	0.0773	0.0836	0.0764	0.0760
119	P 21-22	-0.0183	NA	-0.0194	-0.0184	-0.0015	-0.0184	-0.0184
120	P 15-23	0.0504	NA	0.0496	0.0489	0.0411	0.0486	0.0500
121	P 22-24	0.0574	0.0580	0.0594	0.0580	0.0675	0.0580	0.0580
122	P 23-24	0.0180	0.0179	0.0176	0.0179	0.0081	0.0177	0.0177
123	P 24-25	-0.0121	-0.0118	-0.0084	-0.0102	-0.0018	-0.0105	-0.0104
124	P 25-26	0.0354	0.0357	0.0344	0.0357	0.0457	0.0357	0.0339
125	P 25-27	-0.0476	-0.0480	-0.0473	-0.0480	-0.0393	-0.0480	-0.0480
126	P 28-27	0.1807	0.1793	0.1808	0.1793	0.1893	0.1793	0.1842
127	P 27-29	0.0619	NA	0.0619	0.0615	0.0732	0.0615	0.0631
128	P 27-30	0.0709	0.0722	0.0710	0.0706	0.0799	0.0706	0.0718
129	P 29-30	0.0370	0.0371	0.0372	0.0371	0.0382	0.0371	0.0371
130	P 8-28	-0.0054	NA	-0.0061	-0.0053	0.0047	-0.0054	-0.0054
131	P 6-28	0.1867	NA	0.1811	0.1820	0.2232	0.1840	0.1838
132	P 2-1	-1.6809	-1.6536	-1.6728	-1.6702	-1.6706	-1.6751	-1.6844
133	P 3-1	-0.8454	NA	-0.8434	-0.8416	-0.8495	-0.8443	-0.8457
134	P 4-2	-0.4263	NA	-0.4255	-0.4237	-0.4288	-0.4258	-0.4228
135	P 4-3	-0.8129	-0.8014	-0.8058	-0.8014	-0.7951	-0.8056	-0.8013
136	P 5-2	-0.7942	NA	-0.7920	-0.7908	-0.7878	-0.7911	-0.7909
137	P 6-2	-0.5843	-0.5796	-0.5832	-0.5797	-0.5861	-0.5822	-0.5801
138	P 6-4	-0.7150	NA	-0.7138	-0.7058	-0.7128	-0.7080	-0.7118
139	P 7-5	0.1495	NA	0.1462	0.1491	0.1405	0.1473	0.1491
140	P 7-6	-0.3775	NA	-0.3784	-0.3797	-0.3732	-0.3779	-0.3797
141	P 8-6	-0.2946	NA	-0.2909	-0.2906	-0.3005	-0.2906	-0.2906
142	P 9-6	-0.2772	NA	-0.2776	-0.2796	-0.2641	-0.2777	-0.2793
143	P 10-6	-0.1584	NA	-0.1586	-0.1598	-0.1510	-0.1587	-0.1596
144	P 11-9	0.0000	NA	0.0000	0.0000	-0.0100	0.0000	0.0000
145	P 10-9	-0.2772	-0.2796	-0.2776	-0.2796	-0.2641	-0.2778	-0.2794
146	P 12-4	-0.4419	-0.4497	-0.4422	-0.4381	-0.4400	-0.4422	-0.4439
147	P 13-12	0.0000	NA	0.0000	0.0000	0.0096	0.0000	0.0000
148	P 14-12	-0.0778	NA	-0.0787	-0.0776	-0.0865	-0.0770	-0.0781
149	P 15-12	-0.1767	-0.1733	-0.1731	-0.1733	-0.1832	-0.1738	-0.1763
150	P 16-12	-0.0719	NA	-0.0702	-0.0704	-0.0495	-0.0700	-0.0721
151	P 15-14	-0.0158	NA	-0.0166	-0.0162	-0.0153	-0.0156	-0.0156
152	P 17-16	-0.0368	NA	-0.0344	-0.0354	-0.0244	-0.0350	-0.0355

153	P 18-15	-0.0598	NA	-0.0588	-0.0589	-0.0512	-0.0591	-0.0602
154	P 19-18	-0.0277	NA	-0.0270	-0.0267	-0.0092	-0.0269	-0.0274
155	P 20-19	0.0674	0.0687	0.0682	0.0678	0.0786	0.0683	0.0687
156	P 20-10	-0.0894	-0.0902	-0.0901	-0.0902	-0.1002	-0.0901	-0.0902
157	P 17-10	-0.0532	NA	-0.0536	-0.0534	-0.0434	-0.0534	-0.0534
158	P 21-10	-0.1567	-0.1564	-0.1573	-0.1593	-0.1664	-0.1573	-0.1564
159	P 22-10	-0.0757	NA	-0.0757	-0.0768	-0.0830	-0.0759	-0.0755
160	P 22-21	0.0183	0.0184	0.0194	0.0184	0.0015	0.0184	0.0184
161	P 23-15	-0.0500	-0.0507	-0.0493	-0.0486	-0.0409	-0.0483	-0.0497
162	P 24-22	-0.0569	-0.0568	-0.0589	-0.0575	-0.0668	-0.0575	-0.0575
163	P 24-23	-0.0180	-0.0177	-0.0175	-0.0179	-0.0081	-0.0177	-0.0177
164	P 25-24	0.0122	NA	0.0086	0.0108	0.0019	0.0106	0.0105
165	P 26-25	-0.0350	NA	-0.0340	-0.0354	-0.0450	-0.0353	-0.0335
166	P 27-25	0.0479	NA	0.0475	0.0484	0.0395	0.0483	0.0483
167	P 27-28	-0.1807	-0.1842	-0.1808	-0.1793	-0.1893	-0.1793	-0.1842
168	P 29-27	-0.0610	NA	-0.0611	-0.0607	-0.0719	-0.0607	-0.0622
169	P 30-27	-0.0693	NA	-0.0694	-0.0690	-0.0779	-0.0690	-0.0702
170	P 30-29	-0.0367	-0.0367	-0.0369	-0.0367	-0.0379	-0.0367	-0.0367
171	P 28-8	0.0055	0.0054	0.0061	0.0054	-0.0046	0.0054	0.0054
172	P 28-6	-0.1862	NA	-0.1805	-0.1814	-0.2223	-0.1835	-0.1832
173	Q 1-2	-0.2470	NA	-0.2499	-0.2484	-0.2517	-0.2510	-0.2462
174	Q 1-3	0.0428	0.0421	0.0418	0.0421	0.0361	0.0429	0.0421
175	Q 2-4	0.0475	0.0481	0.0482	0.0492	0.0446	0.0488	0.0466
176	Q 3-4	-0.0385	NA	-0.0353	-0.0308	-0.0276	-0.0387	-0.0377
177	Q 2-5	0.0278	0.0268	0.0267	0.0279	0.0304	0.0285	0.0268
178	Q 2-6	0.0137	NA	0.0155	0.0154	0.0136	0.0155	0.0129
179	Q 4-6	-0.1591	-0.1583	-0.1545	-0.1583	-0.1483	-0.1565	-0.1582
180	Q 5-7	0.1149	0.1149	0.1168	0.1159	0.1083	0.1149	0.1149
181	Q 6-7	-0.0278	-0.0284	-0.0298	-0.0284	-0.0266	-0.0284	-0.0273
182	Q 6-8	-0.0720	-0.0736	-0.0671	-0.0736	-0.0636	-0.0671	-0.0711
183	Q 6-9	-0.0809	-0.0822	-0.0890	-0.0840	-0.0858	-0.0855	-0.0821
184	Q 6-10	0.0019	NA	-0.0024	-0.0008	-0.0019	-0.0010	0.0012
185	Q 9-11	-0.1560	-0.1516	-0.1548	-0.1516	-0.1616	-0.1548	-0.1516
186	Q 9-10	0.0588	NA	0.0526	0.0510	0.0509	0.0530	0.0573
187	Q 4-12	0.1441	NA	0.1438	0.1546	0.1660	0.1438	0.1455
188	Q 12-13	-0.1032	-0.1023	-0.1023	-0.1023	-0.1121	-0.1023	-0.1023
189	Q 12-14	0.0240	0.0237	0.0118	0.0114	0.0138	0.0210	0.0228
190	Q 12-15	0.0679	NA	0.0611	0.0514	0.0698	0.0642	0.0670
191	Q 12-16	0.0335	0.0335	0.0298	0.0234	0.0237	0.0316	0.0322
192	Q 14-15	0.0065	0.0063	0.0150	0.0105	0.0182	0.0076	0.0073
193	Q 16-17	0.0144	NA	0.0086	0.0043	-0.0050	0.0104	0.0130
194	Q 15-18	0.0160	0.0153	0.0157	0.0154	0.0206	0.0154	0.0153

195	Q 18-19	0.0062	0.0059	0.0053	0.0059	-0.0039	0.0059	0.0059
196	Q 19-20	-0.0279	NA	-0.0292	-0.0290	-0.0487	-0.0290	-0.0279
197	Q 10-20	0.0371	NA	0.0395	0.0438	0.0487	0.0388	0.0382
198	Q 10-17	0.0443	0.0449	0.0441	0.0449	0.0303	0.0449	0.0449
199	Q 10-21	0.1001	NA	0.0931	0.0893	0.0881	0.0931	0.0990
200	Q 10-22	0.0460	NA	0.0421	0.0391	0.0399	0.0421	0.0454
201	Q 21-22	-0.0143	NA	-0.0168	-0.0236	-0.0150	-0.0168	-0.0145
202	Q 15-23	0.0291	NA	0.0281	0.0171	0.0273	0.0267	0.0291
203	Q 22-24	0.0306	0.0295	0.0361	0.0315	0.0395	0.0341	0.0315
204	Q 23-24	0.0124	0.0125	0.0123	0.0125	0.0026	0.0125	0.0114
205	Q 24-25	0.0201	0.0196	0.0305	0.0540	0.0163	0.0267	0.0205
206	Q 25-26	0.0237	0.0233	0.0154	-0.0035	0.0282	0.0154	0.0233
207	Q 25-27	-0.0037	-0.0038	-0.0073	-0.0355	-0.0139	-0.0041	-0.0038
208	Q 28-27	0.0504	0.0519	0.0514	0.0482	0.0419	0.0512	0.0489
209	Q 27-29	0.0167	NA	0.0122	0.0127	0.0249	0.0141	0.0176
210	Q 27-30	0.0166	0.0173	0.0147	0.0150	0.0158	0.0156	0.0173
211	Q 29-30	0.0061	0.0060	0.0075	0.0076	-0.0024	0.0070	0.0061
212	Q 8-28	-0.0054	NA	-0.0005	0.0101	0.0064	-0.0040	-0.0022
213	Q 6-27	0.0011	NA	0.0212	0.0526	0.0483	0.0094	0.0129
214	Q 2-1	0.3447	0.3363	0.3461	0.3437	0.3485	0.3475	0.3441
215	Q 3-1	0.0265	NA	0.0271	0.0260	0.0350	0.0261	0.0271
216	Q 4-2	-0.0554	NA	-0.0563	-0.0576	-0.0519	-0.0568	-0.0552
217	Q 4-3	0.0544	0.0525	0.0508	0.0459	0.0424	0.0542	0.0528
218	Q 5-2	0.0517	NA	0.0520	0.0501	0.0478	0.0499	0.0514
219	Q 6-2	0.0058	0.0060	0.0038	0.0029	0.0067	0.0035	0.0055
220	Q 6-4	0.1719	NA	0.1671	0.1704	0.1609	0.1688	0.1707
221	Q 7-5	-0.1313	NA	-0.1333	-0.1323	-0.1251	-0.1314	-0.1314
222	Q 7-6	0.0223	NA	0.0244	0.0229	0.0209	0.0228	0.0218
223	Q 8-6	0.0666	NA	0.0616	0.0681	0.0584	0.0615	0.0656
224	Q 9-6	0.0972	NA	0.1055	0.1006	0.1009	0.1019	0.0986
225	Q 10-6	0.0110	NA	0.0153	0.0138	0.0136	0.0138	0.0118
226	Q 11-9	0.1606	NA	0.1593	0.1559	0.1665	0.1593	0.1559
227	Q 10-9	-0.0508	-0.0521	-0.0447	-0.0430	-0.0436	-0.0451	-0.0493
228	Q 12-4	-0.0972	-0.1004	-0.0969	-0.1079	-0.1179	-0.0969	-0.0982
229	Q 13-12	0.1045	NA	0.1036	0.1036	0.1137	0.1036	0.1036
230	Q 14-12	-0.0225	NA	-0.0103	-0.0099	-0.0120	-0.0196	-0.0213
231	Q 15-12	-0.0636	-0.0629	-0.0571	-0.0475	-0.0652	-0.0601	-0.0627
232	Q 16-12	-0.0324	NA	-0.0288	-0.0224	-0.0231	-0.0305	-0.0310
233	Q 15-14	-0.0064	NA	-0.0149	-0.0105	-0.0181	-0.0075	-0.0072
234	Q 17-16	-0.0141	NA	-0.0084	-0.0041	0.0051	-0.0102	-0.0127
235	Q 18-15	-0.0152	NA	-0.0149	-0.0147	-0.0200	-0.0147	-0.0146
236	Q 19-18	-0.0061	NA	-0.0053	-0.0058	0.0039	-0.0058	-0.0058

237	Q 20-19	0.0283	0.0282	0.0295	0.0293	0.0492	0.0293	0.0282
238	Q 20-10	-0.0353	-0.0363	-0.0376	-0.0419	-0.0463	-0.0369	-0.0363
239	Q 17-10	-0.0439	NA	-0.0437	-0.0445	-0.0301	-0.0445	-0.0445
240	Q 21-10	-0.0977	-0.0957	-0.0908	-0.0870	-0.0857	-0.0908	-0.0967
241	Q 22-10	-0.0449	NA	-0.0411	-0.0381	-0.0387	-0.0411	-0.0444
242	Q 22-21	0.0143	0.0145	0.0168	0.0236	0.0150	0.0168	0.0145
243	Q 23-15	-0.0284	-0.0285	-0.0275	-0.0166	-0.0268	-0.0261	-0.0285
244	Q 24-22	-0.0299	-0.0308	-0.0353	-0.0308	-0.0385	-0.0333	-0.0308
245	Q 24-23	-0.0123	-0.0124	-0.0122	-0.0124	-0.0026	-0.0124	-0.0113
246	Q 25-24	-0.0200	NA	-0.0302	-0.0531	-0.0162	-0.0264	-0.0203
247	Q 26-25	-0.0230	NA	-0.0149	0.0040	-0.0271	-0.0149	-0.0227
248	Q 27-25	0.0042	NA	0.0078	0.0363	0.0143	0.0046	0.0043
249	Q 27-28	-0.0375	-0.0379	-0.0385	-0.0355	-0.0280	-0.0385	-0.0357
250	Q 29-27	-0.0151	NA	-0.0106	-0.0111	-0.0225	-0.0125	-0.0159
251	Q 30-27	-0.0136	NA	-0.0116	-0.0120	-0.0120	-0.0126	-0.0141
252	Q 30-29	-0.0054	-0.0054	-0.0069	-0.0070	0.0031	-0.0064	-0.0054
253	Q 28-8	-0.0380	-0.0395	-0.0429	-0.0534	-0.0495	-0.0394	-0.0413
254	Q 28-6	-0.0123	N/A	-0.0324	-0.0637	-0.0583	-0.0207	-0.0242

B.2.3 Presence of a Multiple Non-interacting Bad-data

Table B.7 IEEE 30 Bus System with five multiple non-interacting bad-data in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	Vm-1	1.0600	1.1047	1.0495	1.0625	1.0633	1.0607	1.0613
2	Vm-2	1.0450	NA	1.0501	1.0478	1.0485	1.0459	1.0462
3	Vm-3	1.0212	1.0212	1.0362	1.0235	1.0225	1.0218	1.0225
4	Vm-4	1.0123	1.0133	1.0256	1.0145	1.0140	1.0130	1.0138
5	Vm-5	1.0100	1.0176	1.0136	1.0127	1.0125	1.0105	1.0115
6	Vm-6	1.0106	NA	1.0227	1.0129	1.0118	1.0112	1.0122
7	Vm-7	1.0026	NA	1.0114	1.0049	1.0054	1.0030	1.0040
8	Vm-8	1.0100	1.0010	1.0214	1.0124	1.0114	1.0104	1.0115
9	Vm-9	1.0511	NA	1.0674	1.0540	1.0505	1.0527	1.0529
10	Vm-10	1.0454	1.0491	1.0636	1.0491	1.0588	1.0476	1.0473
11	Vm-11	1.0820	NA	1.0978	1.0839	1.0805	1.0833	1.0829
12	Vm-12	1.0573	1.0557	1.0671	1.0557	1.0592	1.0583	1.0586
13	Vm-13	1.0710	NA	1.0805	1.0692	1.0740	1.0719	1.0722
14	Vm-14	1.0425	NA	1.0559	1.0436	1.0508	1.0442	1.0441
15	Vm-15	1.0379	NA	1.0523	1.0388	1.0449	1.0395	1.0394
16	Vm-16	1.0446	NA	1.0579	1.0457	1.0531	1.0461	1.0462
17	Vm-17	1.0402	NA	1.0579	1.0438	1.0547	1.0423	1.0421
18	Vm-18	1.0284	1.0294	1.0439	1.0294	1.0394	1.0302	1.0301

19	Vm-19	1.0259	NA	1.0421	1.0270	1.0374	1.0278	1.0276
20	Vm-20	1.0300	NA	1.0465	1.0312	1.0422	1.0320	1.0317
21	Vm-21	1.0330	1.0431	1.0532	1.0376	1.0456	1.0357	1.0350
22	Vm-22	1.0335	NA	1.0541	1.0384	1.0456	1.0363	1.0355
23	Vm-23	1.0274	NA	1.0508	1.0321	1.0364	1.0298	1.0290
24	Vm-24	1.0218	1.1252	1.0466	1.0266	1.0323	1.0242	1.0236
25	Vm-25	1.0176	1.0098	1.0277	1.0098	1.0211	1.0169	1.0188
26	Vm-26	0.9999	1.0022	1.0046	1.0022	1.0023	1.0022	1.0017
27	Vm-27	1.0235	NA	1.0322	1.0234	1.0243	1.0233	1.0248
28	Vm-28	1.0071	1.0052	1.0138	1.0052	1.0082	1.0072	1.0080
29	Vm-29	1.0037	1.0042	1.0053	1.0042	0.9988	1.0042	1.0042
30	Vm-30	0.9922	NA	0.9962	0.9925	0.9857	0.9925	0.9928
31	P-1	2.6096	2.6103	1.4202	2.5984	2.6038	2.6022	2.6139
32	P-2	0.1830	0.1822	0.8556	0.1822	0.1814	0.1825	0.1704
33	P-3	-0.0240	NA	-0.1089	-0.0336	-0.0236	-0.0304	-0.0375
34	P-4	-0.0760	-0.0751	-0.0360	-0.0751	-0.0748	-0.0750	-0.0711
35	P-5	-0.9420	-0.9366	-0.7428	-0.9366	-0.9395	-0.9368	-0.9385
36	P-6	0.0000	NA	0.2008	0.0035	-0.1297	0.0039	0.0123
37	P-7	-0.2280	-0.2306	-0.1889	-0.2306	-0.1602	-0.2306	-0.2306
38	P-8	-0.3000	NA	-0.2965	-0.2959	-0.2861	-0.2960	-0.2960
39	P-9	0.0000	NA	0.0000	0.0000	-0.0470	0.0001	0.0000
40	P-10	-0.0580	-0.0571	-0.0600	-0.0571	-0.0092	-0.0572	-0.0607
41	P-11	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000
42	P-12	-0.1120	NA	-0.1192	-0.1118	-0.1141	-0.1172	-0.1141
43	P-13	0.0000	NA	0.0000	0.0000	0.0098	0.0000	0.0000
44	P-14	-0.0620	-0.0613	-0.0681	-0.0613	-0.0614	-0.0614	-0.0622
45	P-15	-0.0820	-0.0813	-0.0992	-0.0813	-0.0912	-0.0813	-0.0813
46	P-16	-0.0350	-0.0349	-0.0425	-0.0349	-0.0345	-0.0349	-0.0374
47	P-17	-0.0900	NA	-0.0734	-0.0889	-0.0718	-0.0888	-0.0881
48	P-18	-0.0320	-0.0322	-0.0012	-0.0322	-0.0221	-0.0322	-0.0316
49	P-19	-0.0950	-0.0944	-0.0871	-0.0944	-0.0893	-0.0949	-0.0965
50	P-20	-0.0220	NA	-0.0012	-0.0222	-0.0114	-0.0216	-0.0215
51	P-21	-0.1750	-0.1780	-0.1790	-0.1777	-0.1747	-0.1761	-0.1748
52	P-22	0.0000	NA	0.0009	-0.0005	-0.0059	0.0003	0.0012
53	P-23	-0.0320	NA	-0.0374	-0.0305	-0.0330	-0.0312	-0.0320
54	P-24	-0.0870	-0.0856	-0.0744	-0.0856	-0.0755	-0.0856	-0.0856
55	P-25	0.0000	NA	-0.0028	-0.0013	-0.0218	-0.0017	-0.0039
56	P-26	-0.0350	NA	-0.0373	-0.0354	-0.0252	-0.0353	-0.0335
57	P-27	0.0000	NA	-0.0007	0.0013	-0.0178	0.0012	0.0002
58	P-28	0.0000	NA	0.0037	0.0042	0.0173	0.0012	0.0064
59	P-29	-0.0240	-0.0236	-0.0244	-0.0236	-0.0136	-0.0236	-0.0260
60	P-30	-0.1060	-0.1057	-0.1065	-0.1058	-0.1155	-0.1058	-0.1072

61	Q-1	-0.2042	-0.2064	-0.3617	-0.2064	-0.1956	-0.2057	-0.2041
62	Q-2	0.4337	0.4435	0.3027	0.4435	0.4656	0.4403	0.4298
63	Q-3	-0.0120	NA	0.2064	-0.0054	-0.0340	-0.0122	-0.0102
64	Q-4	-0.0160	-0.0154	-0.0268	-0.0154	-0.0146	-0.0152	-0.0150
65	Q-5	0.1666	0.1659	0.0319	0.1659	0.1563	0.1632	0.1663
66	Q-6	0.0000	NA	0.0510	0.0611	-0.0324	-0.0013	0.0094
67	Q-7	-0.1090	-0.1109	-0.1183	-0.1109	-0.1106	-0.1109	-0.1095
68	Q-8	0.0611	NA	0.0680	0.0844	0.0637	0.0575	0.0633
69	Q-9	0.0000	NA	0.0042	0.0000	-0.1405	0.0001	0.0043
70	Q-10	-0.0200	-0.0207	-0.0219	-0.0207	0.1474	-0.0206	-0.0170
71	Q-11	0.1606	NA	0.1602	0.1559	0.1559	0.1593	0.1559
72	Q-12	-0.0750	NA	-0.1485	-0.1353	-0.1807	-0.0806	-0.0789
73	Q-13	0.1045	NA	0.1036	0.1036	0.1137	0.1036	0.1036
74	Q-14	-0.0160	0.0163	0.0013	-0.0038	0.0163	-0.0134	-0.0140
75	Q-15	-0.0250	-0.0255	-0.0323	-0.0255	-0.0156	-0.0255	-0.0255
76	Q-16	-0.0180	-0.0180	-0.0260	-0.0180	-0.0181	-0.0201	-0.0180
77	Q-17	-0.0580	NA	-0.0439	-0.0449	-0.0181	-0.0550	-0.0572
78	Q-18	-0.0090	-0.0087	-0.0250	-0.0094	0.0009	-0.0087	-0.0086
79	Q-19	-0.0340	-0.0348	-0.0376	-0.0348	-0.0449	-0.0348	-0.0337
80	Q-20	-0.0070	NA	-0.0215	-0.0181	-0.0070	-0.0071	-0.0081
81	Q-21	-0.1120	-0.1106	-0.1047	-0.1106	-0.1005	-0.1076	-0.1121
82	Q-22	0.0000	NA	0.0112	0.0215	-0.0229	0.0084	0.0012
83	Q-23	-0.0160	NA	0.0269	0.0022	-0.0112	-0.0129	-0.0168
84	Q-24	-0.0670	-0.0666	-0.0004	-0.0298	-0.0565	-0.0605	-0.0666
85	Q-25	0.0000	NA	-0.0225	-0.1015	0.0086	-0.0191	-0.0011
86	Q-26	-0.0230	NA	-0.0361	0.0040	-0.0328	-0.0149	-0.0227
87	Q-27	0.0000	NA	0.0240	0.0394	0.0176	-0.0011	0.0028
88	Q-28	0.0000	NA	-0.1229	-0.0986	-0.0036	-0.0089	-0.0158
89	Q-29	-0.0090	NA	-0.0313	-0.0069	-0.0247	-0.0067	-0.0098
90	Q-30	-0.0190	-0.0190	-0.0217	-0.0190	-0.0288	-0.0190	-0.0196
91	P 1-2	1.7331	NA	0.7930	1.7244	1.7295	1.7269	1.7356
92	P 1-3	0.8765	0.8707	0.6272	0.8740	0.8743	0.8753	0.8782
93	P 2-4	0.4365	0.4395	0.4303	0.4347	0.4376	0.4360	0.4344
94	P 3-4	0.8214	NA	0.5020	0.8097	0.8199	0.8140	0.8096
95	P 2-5	0.8236	0.8199	0.6698	0.8199	0.8104	0.8202	0.8202
96	P 2-6	0.6038	NA	0.5364	0.6006	0.6113	0.6015	0.5993
97	P 4-6	0.7213	0.7291	0.4721	0.7152	0.7471	0.7142	0.7115
98	P 5-7	-0.1478	-0.1474	-0.0925	-0.1457	-0.1574	-0.1457	-0.1474
99	P 6-7	0.3813	0.3870	0.2840	0.3818	0.3221	0.3818	0.3835
100	P 6-8	0.2956	0.2917	0.2926	0.2917	0.2817	0.2917	0.2917
101	P 6-9	0.2772	0.2717	0.2751	0.2796	0.2717	0.2779	0.2792
102	P 6-10	0.1584	0.1596	0.1572	0.1598	0.1495	0.1588	0.1596

103	P 9-11	0.0000	NA	0.0000	0.0000	-0.0099	0.0000	0.0000
104	P 9-10	0.2772	NA	0.2751	0.2796	0.2346	0.2780	0.2793
105	P 4-12	0.4419	NA	0.4113	0.4357	0.4167	0.4422	0.4432
106	P 12-13	0.0000	NA	0.0000	0.0000	-0.0098	0.0000	0.0000
107	P 12-14	0.0786	0.0800	0.0771	0.0777	0.0779	0.0777	0.0785
108	P 12-15	0.1789	NA	0.1585	0.1753	0.1714	0.1765	0.1778
109	P 12-16	0.0724	0.0727	0.0565	0.0709	0.0631	0.0708	0.0727
110	P 14-15	0.0158	0.0156	0.0083	0.0156	0.0159	0.0156	0.0156
111	P 16-17	0.0369	NA	0.0137	0.0356	0.0283	0.0354	0.0347
112	P 15-18	0.0602	-0.0593	0.0206	0.0591	0.0432	0.0594	0.0599
113	P 18-19	0.0278	0.0281	0.0193	0.0266	0.0209	0.0269	0.0280
114	P 19-20	-0.0673	NA	-0.0678	-0.0678	-0.0685	-0.0681	-0.0685
115	P 10-20	0.0903	NA	0.0699	0.0911	0.0808	0.0907	0.0910
116	P 10-17	0.0533	0.0536	0.0599	0.0536	0.0436	0.0536	0.0536
117	P 10-21	0.1579	NA	0.1635	0.1603	0.1678	0.1588	0.1576
118	P 10-22	0.0762	NA	0.0791	0.0773	0.0827	0.0766	0.0760
119	P 21-22	-0.0183	NA	-0.0165	-0.0184	-0.0082	-0.0184	-0.0184
120	P 15-23	0.0504	NA	0.0454	0.0485	0.0510	0.0492	0.0500
121	P 22-24	0.0574	0.0580	0.0630	0.0580	0.0680	0.0580	0.0583
122	P 23-24	0.0180	0.0179	0.0078	0.0177	0.0178	0.0177	0.0177
123	P 24-25	-0.0121	-0.0118	-0.0041	-0.0104	0.0095	-0.0105	-0.0102
124	P 25-26	0.0354	0.0357	0.0380	0.0357	0.0256	0.0357	0.0339
125	P 25-27	-0.0476	-0.0480	-0.0455	-0.0480	-0.0380	-0.0480	-0.0480
126	P 28-27	0.1807	0.1793	0.1805	0.1793	0.1885	0.1793	0.1842
127	P 27-29	0.0619	NA	0.0625	0.0615	0.0584	0.0615	0.0639
128	P 27-30	0.0709	0.0722	0.0716	0.0706	0.0740	0.0706	0.0722
129	P 29-30	0.0370	0.0371	0.0370	0.0371	0.0439	0.0371	0.0369
130	P 8-28	-0.0054	NA	-0.0049	-0.0053	-0.0054	-0.0054	-0.0054
131	P 6-28	0.1867	NA	0.1826	0.1811	0.1771	0.1840	0.1838
132	P 2-1	-1.6809	1.6536	-0.7809	-1.6730	-1.6779	-1.6752	-1.6835
133	P 3-1	-0.8454	NA	-0.6109	-0.8433	-0.8435	-0.8443	-0.8471
134	P 4-2	-0.4263	NA	-0.4207	-0.4246	-0.4273	-0.4258	-0.4244
135	P 4-3	-0.8129	-0.8014	-0.4987	-0.8014	-0.8114	-0.8056	-0.8013
136	P 5-2	-0.7942	NA	-0.6503	-0.7908	-0.7821	-0.7911	-0.7910
137	P 6-2	-0.5843	-0.5796	-0.5212	-0.5815	-0.5914	-0.5822	-0.5802
138	P 6-4	-0.7150	NA	-0.4696	-0.7091	-0.7404	-0.7080	-0.7053
139	P 7-5	0.1495	NA	0.0930	0.1474	0.1592	0.1474	0.1491
140	P 7-6	-0.3775	NA	-0.2819	-0.3780	-0.3194	-0.3780	-0.3797
141	P 8-6	-0.2946	NA	-0.2916	-0.2906	-0.2807	-0.2906	-0.2906
142	P 9-6	-0.2772	NA	-0.2751	-0.2796	-0.2717	-0.2779	-0.2792
143	P 10-6	-0.1584	NA	-0.1572	-0.1598	-0.1495	-0.1588	-0.1596
144	P 11-9	0.0000	NA	0.0000	0.0000	0.0099	0.0000	0.0000

145	P 10-9	-0.2772	-0.2796	-0.2751	-0.2796	-0.2346	-0.2780	-0.2793
146	P 12-4	-0.4419	-0.4497	-0.4113	-0.4357	-0.4167	-0.4422	-0.4432
147	P 13-12	0.0000	NA	0.0000	0.0000	0.0098	0.0000	0.0000
148	P 14-12	-0.0778	NA	-0.0765	-0.0770	-0.0773	-0.0770	-0.0778
149	P 15-12	-0.1767	-0.1733	-0.1569	-0.1733	-0.1696	-0.1744	-0.1757
150	P 16-12	-0.0719	NA	-0.0562	-0.0705	-0.0628	-0.0703	-0.0722
151	P 15-14	-0.0158	NA	-0.0083	-0.0156	-0.0158	-0.0156	-0.0156
152	P 17-16	-0.0368	NA	-0.0137	-0.0355	-0.0283	-0.0354	-0.0347
153	P 18-15	-0.0598	NA	-0.0205	-0.0587	-0.0430	-0.0591	-0.0596
154	P 19-18	-0.0277	NA	-0.0193	-0.0265	-0.0209	-0.0268	-0.0279
155	P 20-19	0.0674	0.0687	0.0680	0.0680	0.0686	0.0683	0.0687
156	P 20-10	-0.0894	-0.0902	-0.0692	-0.0902	-0.0800	-0.0899	-0.0902
157	P 17-10	-0.0532	NA	-0.0598	-0.0534	-0.0435	-0.0534	-0.0534
158	P 21-10	-0.1567	-0.1564	-0.1625	-0.1593	-0.1665	-0.1577	-0.1565
159	P 22-10	-0.0757	NA	-0.0786	-0.0768	-0.0821	-0.0761	-0.0755
160	P 22-21	0.0183	0.0184	0.0165	0.0184	0.0082	0.0184	0.0184
161	P 23-15	-0.0500	-0.0507	-0.0452	-0.0483	-0.0507	-0.0489	-0.0497
162	P 24-22	-0.0569	-0.0568	-0.0626	-0.0575	-0.0674	-0.0575	-0.0578
163	P 24-23	-0.0180	-0.0177	-0.0078	-0.0177	-0.0177	-0.0177	-0.0177
164	P 25-24	0.0122	NA	0.0047	0.0111	-0.0094	0.0106	0.0103
165	P 26-25	-0.0350	NA	-0.0373	-0.0354	-0.0252	-0.0353	-0.0335
166	P 27-25	0.0479	NA	0.0457	0.0485	0.0382	0.0483	0.0483
167	P 27-28	-0.1807	-0.1842	-0.1805	-0.1793	-0.1885	-0.1793	-0.1842
168	P 29-27	-0.0610	NA	-0.0614	-0.0607	-0.0575	-0.0607	-0.0630
169	P 30-27	-0.0693	NA	-0.0699	-0.0690	-0.0721	-0.0690	-0.0706
170	P 30-29	-0.0367	-0.0367	-0.0367	-0.0367	-0.0434	-0.0367	-0.0366
171	P 28-8	0.0055	0.0054	0.0050	0.0054	0.0054	0.0054	0.0054
172	P 28-6	-0.1862	NA	-0.1819	-0.1805	-0.1765	-0.1835	-0.1832
173	Q 1-2	-0.2470	NA	-0.2839	-0.2504	-0.2509	-0.2491	-0.2462
174	Q 1-3	0.0428	0.0421	-0.0778	0.0440	0.0553	0.0434	0.0421
175	Q 2-4	0.0475	0.0481	0.0010	0.0518	0.0585	0.0489	0.0465
176	Q 3-4	-0.0385	NA	0.1135	-0.0294	-0.0469	-0.0377	-0.0375
177	Q 2-5	0.0278	0.0268	0.0507	0.0287	0.0344	0.0300	0.0267
178	Q 2-6	0.0137	NA	-0.0110	0.0175	0.0261	0.0161	0.0128
179	Q 4-6	-0.1591	-0.1583	-0.0642	-0.1604	-0.1525	-0.1544	-0.1582
180	Q 5-7	0.1149	0.1149	0.0455	0.1171	0.1160	0.1149	0.1149
181	Q 6-7	-0.0278	-0.0284	0.0421	-0.0284	-0.0305	-0.0261	-0.0273
182	Q 6-8	-0.0720	-0.0736	-0.0554	-0.0736	-0.0736	-0.0671	-0.0711
183	Q 6-9	-0.0809	-0.0822	-0.1022	-0.0837	-0.0722	-0.0859	-0.0821
184	Q 6-10	0.0019	NA	-0.0093	-0.0005	-0.0218	-0.0012	0.0012
185	Q 9-11	-0.1560	-0.1516	-0.1557	-0.1516	-0.1516	-0.1548	-0.1516
186	Q 9-10	0.0588	NA	0.0413	0.0514	-0.0765	0.0526	0.0573

187	Q 4-12	0.1441	NA	0.1618	0.1608	0.1416	0.1430	0.1455
188	Q 12-13	-0.1032	-0.1023	-0.1023	-0.1023	-0.1122	-0.1023	-0.1023
189	Q 12-14	0.0240	0.0237	0.0100	0.0129	-0.0018	0.0218	0.0228
190	Q 12-15	0.0679	NA	0.0416	0.0486	0.0304	0.0642	0.0669
191	Q 12-16	0.0335	0.0335	0.0227	0.0196	0.0027	0.0319	0.0321
192	Q 14-15	0.0065	0.0063	0.0099	0.0077	0.0131	0.0069	0.0073
193	Q 16-17	0.0144	NA	-0.0039	0.0006	-0.0161	0.0107	0.0129
194	Q 15-18	0.0160	0.0153	0.0302	0.0161	0.0053	0.0154	0.0153
195	Q 18-19	0.0062	0.0059	0.0050	0.0059	0.0059	0.0059	0.0060
196	Q 19-20	-0.0279	NA	-0.0326	-0.0290	-0.0390	-0.0290	-0.0279
197	Q 10-20	0.0371	NA	0.0559	0.0494	0.0481	0.0383	0.0382
198	Q 10-17	0.0443	0.0449	0.0483	0.0449	0.0347	0.0449	0.0449
199	Q 10-21	0.1001	NA	0.0721	0.0866	0.1084	0.0931	0.1000
200	Q 10-22	0.0460	NA	0.0288	0.0373	0.0532	0.0421	0.0459
201	Q 21-22	-0.0143	NA	-0.0347	-0.0263	0.0053	-0.0168	-0.0145
202	Q 15-23	0.0291	NA	-0.0141	0.0108	0.0190	0.0260	0.0291
203	Q 22-24	0.0306	0.0295	0.0043	0.0315	0.0342	0.0327	0.0315
204	Q 23-24	0.0124	0.0125	0.0124	0.0125	0.0072	0.0125	0.0117
205	Q 24-25	0.0201	0.0196	0.0627	0.0587	0.0296	0.0290	0.0208
206	Q 25-26	0.0237	0.0233	0.0371	-0.0035	0.0335	0.0154	0.0233
207	Q 25-27	-0.0037	-0.0038	0.0019	-0.0404	0.0044	-0.0059	-0.0038
208	Q 28-27	0.0504	0.0519	0.0459	0.0455	0.0519	0.0512	0.0497
209	Q 27-29	0.0167	NA	0.0342	0.0152	0.0324	0.0150	0.0176
210	Q 27-30	0.0166	0.0173	0.0246	0.0160	0.0273	0.0160	0.0173
211	Q 29-30	0.0061	0.0060	0.0009	0.0066	0.0059	0.0067	0.0061
212	Q 8-28	-0.0054	NA	0.0185	0.0163	-0.0041	-0.0040	-0.0022
213	Q 6-27	0.0011	NA	0.0953	0.0736	0.0046	0.0094	0.0129
214	Q 2-1	0.3447	0.3363	0.2619	0.3456	0.3466	0.3454	0.3438
215	Q 3-1	0.0265	NA	0.0929	0.0240	0.0129	0.0255	0.0273
216	Q 4-2	-0.0554	NA	-0.0114	-0.0602	-0.0664	-0.0569	-0.0549
217	Q 4-3	0.0544	0.0525	-0.1131	0.0444	0.0626	0.0531	0.0526
218	Q 5-2	0.0517	NA	-0.0136	0.0489	0.0402	0.0483	0.0514
219	Q 6-2	0.0058	0.0060	0.0168	0.0010	-0.0055	0.0029	0.0056
220	Q 6-4	0.1719	NA	0.0636	0.1727	0.1666	0.1667	0.1703
221	Q 7-5	-0.1313	NA	-0.0651	-0.1336	-0.1322	-0.1314	-0.1314
222	Q 7-6	0.0223	NA	-0.0532	0.0227	0.0215	0.0205	0.0219
223	Q 8-6	0.0666	NA	0.0495	0.0681	0.0678	0.0615	0.0655
224	Q 9-6	0.0972	NA	0.1186	0.1002	0.0875	0.1024	0.0986
225	Q 10-6	0.0110	NA	0.0217	0.0135	0.0335	0.0141	0.0118
226	Q 11-9	0.1606	NA	0.1602	0.1559	0.1559	0.1593	0.1559
227	Q 10-9	-0.0508	-0.0521	-0.0338	-0.0434	0.0826	-0.0446	-0.0493
228	Q 12-4	-0.0972	-0.1004	-0.1205	-0.1142	-0.0997	-0.0962	-0.0985

229	Q 13-12	0.1045	NA	0.1036	0.1036	0.1137	0.1036	0.1036
230	Q 14-12	-0.0225	NA	-0.0087	-0.0115	0.0032	-0.0203	-0.0213
231	Q 15-12	-0.0636	-0.0629	-0.0385	-0.0447	-0.0268	-0.0601	-0.0627
232	Q 16-12	-0.0324	NA	-0.0221	-0.0187	-0.0020	-0.0308	-0.0310
233	Q 15-14	-0.0064	NA	-0.0099	-0.0076	-0.0130	-0.0068	-0.0072
234	Q 17-16	-0.0141	NA	0.0040	-0.0004	0.0163	-0.0105	-0.0127
235	Q 18-15	-0.0152	NA	-0.0300	-0.0153	-0.0050	-0.0147	-0.0146
236	Q 19-18	-0.0061	NA	-0.0050	-0.0058	-0.0058	-0.0058	-0.0059
237	Q 20-19	0.0283	0.0282	0.0330	0.0293	0.0394	0.0293	0.0282
238	Q 20-10	-0.0353	-0.0363	-0.0545	-0.0474	-0.0464	-0.0364	-0.0363
239	Q 17-10	-0.0439	NA	-0.0479	-0.0445	-0.0344	-0.0445	-0.0445
240	Q 21-10	-0.0977	-0.0957	-0.0699	-0.0843	-0.1057	-0.0908	-0.0976
241	Q 22-10	-0.0449	NA	-0.0279	-0.0363	-0.0519	-0.0411	-0.0448
242	Q 22-21	0.0143	0.0145	0.0347	0.0263	-0.0052	0.0168	0.0145
243	Q 23-15	-0.0284	-0.0285	0.0146	-0.0103	-0.0184	-0.0254	-0.0285
244	Q 24-22	-0.0299	-0.0308	-0.0037	-0.0308	-0.0333	-0.0320	-0.0308
245	Q 24-23	-0.0123	-0.0124	-0.0123	-0.0124	-0.0071	-0.0124	-0.0116
246	Q 25-24	-0.0200	NA	-0.0615	-0.0575	-0.0293	-0.0287	-0.0206
247	Q 26-25	-0.0230	NA	-0.0361	0.0040	-0.0328	-0.0149	-0.0227
248	Q 27-25	0.0042	NA	-0.0015	0.0412	-0.0041	0.0064	0.0043
249	Q 27-28	-0.0375	-0.0379	-0.0334	-0.0330	-0.0379	-0.0385	-0.0364
250	Q 29-27	-0.0151	NA	-0.0322	-0.0136	-0.0306	-0.0134	-0.0159
251	Q 30-27	-0.0136	NA	-0.0214	-0.0130	-0.0237	-0.0130	-0.0141
252	Q 30-29	-0.0054	-0.0054	-0.0003	-0.0060	-0.0050	-0.0061	-0.0054
253	Q 28-8	-0.0380	-0.0395	-0.0625	-0.0596	-0.0394	-0.0395	-0.0413
254	Q 28-6	-0.0123	N/A	-0.1063	-0.0845	-0.0160	-0.0207	-0.0241

B.2.4 Presence of a Multiple Interacting Bad-data

Table B.8 IEEE 30 Bus System with five multiple interacting bad-data in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	Vm-1	1.0600	1.0600	1.0438	1.0608	1.0614	1.0601	1.0623
2	Vm-2	1.0450	NA	1.0512	1.0460	1.0468	1.0455	1.0473
3	Vm-3	1.0212	1.0212	1.0258	1.0221	1.0219	1.0213	1.0235
4	Vm-4	1.0123	1.0133	1.0176	1.0133	1.0133	1.0126	1.0148
5	Vm-5	1.0100	1.0676	1.0446	1.0112	1.0138	1.0106	1.0126
6	Vm-6	1.0106	NA	1.0158	1.0117	1.0120	1.0108	1.0131
7	Vm-7	1.0026	NA	1.0135	1.0037	1.0050	1.0029	1.0051
8	Vm-8	1.0100	1.0010	1.0148	1.0112	1.0110	1.0100	1.0125
9	Vm-9	1.0511	NA	1.0554	1.0529	1.0525	1.0522	1.0539

10	Vm-10	1.0454	1.0491	1.0495	1.0479	1.0472	1.0471	1.0483
11	Vm-11	1.0820	NA	1.0855	1.0828	1.0844	1.0828	1.0838
12	Vm-12	1.0573	1.0557	1.0587	1.0577	1.0550	1.0578	1.0597
13	Vm-13	1.0710	NA	1.0722	1.0712	1.0699	1.0713	1.0732
14	Vm-14	1.0425	NA	1.0442	1.0431	1.0410	1.0433	1.0449
15	Vm-15	1.0379	NA	1.0399	1.0387	1.0364	1.0388	1.0404
16	Vm-16	1.0446	NA	1.0471	1.0461	1.0450	1.0455	1.0472
17	Vm-17	1.0402	NA	1.0441	1.0427	1.0412	1.0418	1.0430
18	Vm-18	1.0284	1.0294	1.0308	1.0294	1.0286	1.0295	1.0310
19	Vm-19	1.0259	NA	1.0286	1.0270	1.0278	1.0271	1.0286
20	Vm-20	1.0300	NA	1.0328	1.0312	1.0323	1.0313	1.0327
21	Vm-21	1.0330	1.0431	1.0373	1.0363	1.0354	1.0351	1.0361
22	Vm-22	1.0335	NA	1.0378	1.0370	1.0361	1.0357	1.0367
23	Vm-23	1.0274	NA	1.0301	1.0307	1.0266	1.0291	1.0301
24	Vm-24	1.0218	1.0252	1.0247	1.0252	1.0218	1.0235	1.0248
25	Vm-25	1.0176	1.0098	1.0161	1.0098	1.0126	1.0169	1.0201
26	Vm-26	0.9999	1.0022	1.0012	1.0022	0.9922	1.0022	1.0030
27	Vm-27	1.0235	NA	1.0234	1.0225	1.0174	1.0229	1.0261
28	Vm-28	1.0071	1.0052	1.0085	1.0052	1.0052	1.0068	1.0089
29	Vm-29	1.0037	1.0042	1.0041	1.0042	1.0014	1.0042	1.0056
30	Vm-30	0.9922	NA	0.9923	0.9921	0.9894	0.9923	0.9941
31	P-1	2.6096	2.6103	0.8981	2.5958	2.5940	2.6015	2.6108
32	P-2	0.1830	0.1822	0.4460	0.1822	0.1719	0.1860	0.1748
33	P-3	-0.0240	NA	0.3730	-0.0328	-0.0192	-0.0308	-0.0368
34	P-4	-0.0760	-0.0751	-0.0375	-0.0751	-0.0649	-0.0749	-0.0620
35	P-5	-0.9420	0.9366	0.2769	-0.9382	-0.9130	-0.9359	-0.9380
36	P-6	0.0000	NA	-0.1120	0.0138	0.0516	0.0000	0.0013
37	P-7	-0.2280	-0.2306	-0.4696	-0.2306	-0.2405	-0.2304	-0.2306
38	P-8	-0.3000	NA	-0.2964	-0.2959	-0.2959	-0.2960	-0.2959
39	P-9	0.0000	NA	0.0000	0.0000	-0.0022	0.0001	0.0000
40	P-10	-0.0580	-0.0571	-0.0567	-0.0571	-0.0470	-0.0572	-0.0607
41	P-11	0.0000	NA	0.0000	0.0000	0.0101	0.0000	0.0000
42	P-12	-0.1120	NA	-0.0866	-0.1168	-0.1271	-0.1164	-0.1145
43	P-13	0.0000	NA	0.0000	0.0000	0.0098	0.0000	0.0000
44	P-14	-0.0620	-0.0613	-0.0619	-0.0613	-0.0712	-0.0614	-0.0621
45	P-15	-0.0820	-0.0813	-0.0807	-0.0813	-0.0721	-0.0814	-0.0813
46	P-16	-0.0350	-0.0349	-0.0353	-0.0349	-0.0252	-0.0349	-0.0366
47	P-17	-0.0900	NA	-0.0891	-0.0887	-0.0908	-0.0890	-0.0889
48	P-18	-0.0320	-0.0322	-0.0319	-0.0322	-0.0420	-0.0322	-0.0328
49	P-19	-0.0950	-0.0944	-0.0950	-0.0944	-0.0996	-0.0949	-0.0959
50	P-20	-0.0220	NA	-0.0216	-0.0224	-0.0215	-0.0214	-0.0215
51	P-21	-0.1750	-0.1780	-0.1767	-0.1777	-0.1748	-0.1761	-0.1748

52	P-22	0.0000	NA	0.0032	-0.0005	-0.0062	0.0003	0.0009
53	P-23	-0.0320	NA	-0.0317	-0.0312	-0.0520	-0.0313	-0.0320
54	P-24	-0.0870	-0.0856	-0.0849	-0.0856	-0.0773	-0.0856	-0.0856
55	P-25	0.0000	NA	-0.0047	-0.0014	0.0018	-0.0018	-0.0036
56	P-26	-0.0350	NA	-0.0342	-0.0354	-0.0450	-0.0353	-0.0335
57	P-27	0.0000	NA	0.0001	0.0012	0.0026	0.0009	0.0001
58	P-28	0.0000	NA	0.0039	0.0033	-0.0377	0.0014	0.0063
59	P-29	-0.0240	-0.0236	-0.0239	-0.0236	-0.0268	-0.0236	-0.0258
60	P-30	-0.1060	-0.1057	-0.1063	-0.1057	-0.1157	-0.1058	-0.1073
61	Q-1	-0.2042	-0.2064	-0.3303	-0.2064	-0.2040	-0.2092	-0.2058
62	Q-2	0.4337	0.4435	0.4003	0.4340	0.4358	0.4399	0.4326
63	Q-3	-0.0120	NA	-0.0519	-0.0108	-0.0274	-0.0122	-0.0110
64	Q-4	-0.0160	-0.0154	-0.0284	-0.0154	-0.0075	-0.0153	-0.0155
65	Q-5	0.1666	0.1659	0.0862	0.1659	0.1761	0.1678	0.1660
66	Q-6	0.0000	NA	0.0168	0.0408	0.0499	0.0003	0.0081
67	Q-7	-0.1090	-0.1109	-0.1265	-0.1088	-0.1046	-0.1104	-0.1088
68	Q-8	0.0611	NA	0.0669	0.0784	0.0644	0.0575	0.0632
69	Q-9	0.0000	NA	0.0009	0.0000	-0.0100	0.0001	0.0043
70	Q-10	-0.0200	-0.0207	-0.0211	-0.0207	-0.0307	-0.0206	-0.0210
71	Q-11	0.1606	NA	0.1568	0.1559	0.1665	0.1593	0.1559
72	Q-12	-0.0750	NA	-0.1049	-0.0855	-0.1241	-0.0793	-0.0779
73	Q-13	0.1045	NA	0.1036	0.1036	0.1137	0.1036	0.1036
74	Q-14	-0.0160	-0.0163	-0.0155	-0.0163	-0.0063	-0.0153	-0.0157
75	Q-15	-0.0250	-0.0255	-0.0260	-0.0345	-0.0354	-0.0255	-0.0255
76	Q-16	-0.0180	-0.0180	-0.0207	-0.0180	-0.0121	-0.0201	-0.0180
77	Q-17	-0.0580	NA	-0.0523	-0.0534	-0.0649	-0.0548	-0.0574
78	Q-18	-0.0090	-0.0087	-0.0095	-0.0087	-0.0096	-0.0087	-0.0086
79	Q-19	-0.0340	-0.0348	-0.0342	-0.0348	-0.0248	-0.0348	-0.0337
80	Q-20	-0.0070	NA	-0.0112	-0.0126	0.0013	-0.0079	-0.0081
81	Q-21	-0.1120	-0.1106	-0.1095	-0.1106	-0.1101	-0.1076	-0.1097
82	Q-22	0.0000	NA	0.0082	0.0169	0.0268	0.0092	0.0024
83	Q-23	-0.0160	NA	-0.0132	-0.0041	-0.0052	-0.0129	-0.0165
84	Q-24	-0.0670	-0.0666	-0.0625	-0.0342	-0.0681	-0.0635	-0.0666
85	Q-25	0.0000	NA	-0.0247	-0.0930	-0.0042	-0.0149	-0.0009
86	Q-26	-0.0230	NA	-0.0163	0.0040	-0.0229	-0.0149	-0.0227
87	Q-27	0.0000	NA	0.0003	0.0301	-0.0366	-0.0044	0.0035
88	Q-28	0.0000	NA	-0.0772	-0.0700	-0.0455	-0.0089	-0.0165
89	Q-29	-0.0090	NA	-0.0071	-0.0040	0.0036	-0.0054	-0.0098
90	Q-30	-0.0190	-0.0190	-0.0189	-0.0190	-0.0089	-0.0190	-0.0196
91	P 1-2	1.7331	NA	0.5353	1.7224	1.7244	1.7257	1.7335
92	P 1-3	0.8765	-0.8707	0.3628	0.8734	0.8696	0.8758	0.8773
93	P 2-4	0.4365	0.4395	0.3315	0.4345	0.4338	0.4368	0.4344

94	P 3-4	0.8214	NA	0.7303	0.8097	0.8198	0.8140	0.8095
95	P 2-5	0.8236	0.8199	0.1728	0.8199	0.8102	0.8205	0.8208
96	P 2-6	0.6038	NA	0.4703	0.5989	0.6008	0.6027	0.6012
97	P 4-6	0.7213	0.7291	0.5982	0.7092	0.7191	0.7155	0.7195
98	P 5-7	-0.1478	-0.1474	0.4485	-0.1474	-0.1311	-0.1446	-0.1463
99	P 6-7	0.3813	0.3870	0.0302	0.3835	0.3769	0.3805	0.3824
100	P 6-8	0.2956	0.2917	0.2923	0.2917	0.3016	0.2917	0.2916
101	P 6-9	0.2772	0.2717	0.2769	0.2796	0.2816	0.2777	0.2792
102	P 6-10	0.1584	0.1596	0.1582	0.1598	0.1625	0.1587	0.1595
103	P 9-11	0.0000	NA	0.0000	0.0000	-0.0101	0.0000	0.0000
104	P 9-10	0.2772	NA	0.2769	0.2796	0.2896	0.2778	0.2792
105	P 4-12	0.4419	NA	0.4132	0.4416	0.4510	0.4418	0.4441
106	P 12-13	0.0000	NA	0.0000	0.0000	-0.0098	0.0000	0.0000
107	P 12-14	0.0786	0.0800	0.0779	0.0775	0.0855	0.0776	0.0785
108	P 12-15	0.1789	NA	0.1769	0.1765	0.1855	0.1767	0.1784
109	P 12-16	0.0724	0.0727	0.0718	0.0707	0.0628	0.0711	0.0727
110	P 14-15	0.0158	0.0156	0.0153	0.0154	0.0135	0.0155	0.0156
111	P 16-17	0.0369	NA	0.0360	0.0353	0.0372	0.0356	0.0355
112	P 15-18	0.0602	0.0593	0.0595	0.0593	0.0636	0.0594	0.0606
113	P 18-19	0.0278	0.0281	0.0272	0.0268	0.0211	0.0269	0.0274
114	P 19-20	-0.0673	NA	-0.0679	-0.0676	-0.0785	-0.0681	-0.0685
115	P 10-20	0.0903	NA	0.0906	0.0911	0.1011	0.0905	0.0910
116	P 10-17	0.0533	0.0536	0.0533	0.0536	0.0538	0.0536	0.0535
117	P 10-21	0.1579	NA	0.1583	0.1604	0.1676	0.1588	0.1575
118	P 10-22	0.0762	NA	0.0762	0.0773	0.0825	0.0766	0.0760
119	P 21-22	-0.0183	NA	-0.0194	-0.0184	-0.0083	-0.0184	-0.0184
120	P 15-23	0.0504	NA	0.0498	0.0492	0.0610	0.0493	0.0500
121	P 22-24	0.0574	0.0580	0.0595	0.0580	0.0675	0.0580	0.0580
122	P 23-24	0.0180	0.0179	0.0179	0.0177	0.0087	0.0177	0.0177
123	P 24-25	-0.0121	-0.0118	-0.0081	-0.0104	-0.0018	-0.0105	-0.0104
124	P 25-26	0.0354	0.0357	0.0346	0.0357	0.0457	0.0357	0.0339
125	P 25-27	-0.0476	-0.0480	-0.0476	-0.0480	-0.0459	-0.0480	-0.0480
126	P 28-27	0.1807	0.1793	0.1808	0.1793	0.1893	0.1795	0.1842
127	P 27-29	0.0619	NA	0.0620	0.0615	0.0682	0.0615	0.0638
128	P 27-30	0.0709	0.0722	0.0711	0.0706	0.0776	0.0706	0.0722
129	P 29-30	0.0370	0.0371	0.0372	0.0371	0.0403	0.0371	0.0371
130	P 8-28	-0.0054	NA	-0.0052	-0.0053	0.0047	-0.0054	-0.0054
131	P 6-28	0.1867	NA	0.1827	0.1820	0.2232	0.1840	0.1838
132	P 2-1	-1.6809	1.6536	-0.5286	-1.6710	-1.6729	-1.6740	-1.6815
133	P 3-1	-0.8454	NA	-0.3573	-0.8426	-0.8390	-0.8447	-0.8463
134	P 4-2	-0.4263	NA	-0.3253	-0.4244	-0.4238	-0.4266	-0.4244
135	P 4-3	-0.8129	-0.8014	-0.7236	-0.8014	-0.8113	-0.8056	-0.8012

136	P 5-2	-0.7942	NA	-0.1716	-0.7907	-0.7818	-0.7913	-0.7917
137	P 6-2	-0.5843	-0.5796	-0.4584	-0.5798	-0.5816	-0.5833	-0.5820
138	P 6-4	-0.7150	NA	-0.5939	-0.7031	-0.7128	-0.7093	-0.7132
139	P 7-5	0.1495	NA	-0.4395	0.1491	0.1327	0.1462	0.1480
140	P 7-6	-0.3775	NA	-0.0302	-0.3797	-0.3732	-0.3767	-0.3786
141	P 8-6	-0.2946	NA	-0.2913	-0.2906	-0.3005	-0.2906	-0.2906
142	P 9-6	-0.2772	NA	-0.2769	-0.2796	-0.2816	-0.2777	-0.2792
143	P 10-6	-0.1584	NA	-0.1582	-0.1598	-0.1625	-0.1587	-0.1595
144	P 11-9	0.0000	NA	0.0000	0.0000	0.0101	0.0000	0.0000
145	P 10-9	-0.2772	-0.2796	-0.2769	-0.2796	-0.2896	-0.2778	-0.2792
146	P 12-4	-0.4419	-0.4497	-0.4132	-0.4416	-0.4510	-0.4418	-0.4441
147	P 13-12	0.0000	NA	0.0000	0.0000	0.0098	0.0000	0.0000
148	P 14-12	-0.0778	NA	-0.0772	-0.0768	-0.0846	-0.0769	-0.0778
149	P 15-12	-0.1767	-0.1733	-0.1748	-0.1744	-0.1832	-0.1746	-0.1763
150	P 16-12	-0.0719	NA	-0.0713	-0.0702	-0.0624	-0.0705	-0.0721
151	P 15-14	-0.0158	NA	-0.0152	-0.0154	-0.0134	-0.0155	-0.0156
152	P 17-16	-0.0368	NA	-0.0360	-0.0353	-0.0371	-0.0356	-0.0355
153	P 18-15	-0.0598	NA	-0.0591	-0.0589	-0.0631	-0.0591	-0.0602
154	P 19-18	-0.0277	NA	-0.0271	-0.0267	-0.0211	-0.0269	-0.0274
155	P 20-19	0.0674	0.0687	0.0680	0.0678	0.0787	0.0683	0.0687
156	P 20-10	-0.0894	-0.0902	-0.0897	-0.0902	-0.1002	-0.0896	-0.0902
157	P 17-10	-0.0532	NA	-0.0532	-0.0534	-0.0536	-0.0534	-0.0534
158	P 21-10	-0.1567	-0.1564	-0.1572	-0.1593	-0.1665	-0.1577	-0.1564
159	P 22-10	-0.0757	NA	-0.0757	-0.0768	-0.0820	-0.0761	-0.0755
160	P 22-21	0.0183	0.0184	0.0194	0.0184	0.0084	0.0184	0.0184
161	P 23-15	-0.0500	-0.0507	-0.0496	-0.0489	-0.0607	-0.0490	-0.0497
162	P 24-22	-0.0569	-0.0568	-0.0589	-0.0575	-0.0668	-0.0575	-0.0575
163	P 24-23	-0.0180	-0.0177	-0.0178	-0.0177	-0.0086	-0.0177	-0.0177
164	P 25-24	0.0122	NA	0.0083	0.0110	0.0020	0.0106	0.0105
165	P 26-25	-0.0350	NA	-0.0342	-0.0354	-0.0450	-0.0353	-0.0335
166	P 27-25	0.0479	NA	0.0479	0.0484	0.0461	0.0483	0.0483
167	P 27-28	-0.1807	-0.1842	-0.1808	-0.1793	-0.1893	-0.1795	-0.1842
168	P 29-27	-0.0610	NA	-0.0611	-0.0607	-0.0672	-0.0607	-0.0628
169	P 30-27	-0.0693	NA	-0.0694	-0.0690	-0.0757	-0.0690	-0.0706
170	P 30-29	-0.0367	-0.0367	-0.0368	-0.0367	-0.0399	-0.0367	-0.0367
171	P 28-8	0.0055	0.0054	0.0052	0.0054	-0.0046	0.0054	0.0054
172	P 28-6	-0.1862	NA	-0.1821	-0.1814	-0.2224	-0.1835	-0.1832
173	Q 1-2	-0.2470	NA	-0.3319	-0.2487	-0.2521	-0.2518	-0.2481
174	Q 1-3	0.0428	0.0421	0.0016	0.0424	0.0481	0.0426	0.0423
175	Q 2-4	0.0475	0.0481	0.0813	0.0481	0.0528	0.0488	0.0473
176	Q 3-4	-0.0385	NA	-0.0267	-0.0368	-0.0466	-0.0387	-0.0377
177	Q 2-5	0.0278	-0.0268	-0.0266	0.0274	0.0187	0.0273	0.0268

178	Q 2-6	0.0137	NA	0.0518	0.0144	0.0166	0.0156	0.0136
179	Q 4-6	-0.1591	-0.1583	-0.1241	-0.1583	-0.1683	-0.1563	-0.1583
180	Q 5-7	0.1149	0.1149	0.1001	0.1153	0.1201	0.1167	0.1149
181	Q 6-7	-0.0278	-0.0284	0.0101	-0.0284	-0.0383	-0.0283	-0.0283
182	Q 6-8	-0.0720	-0.0736	-0.0613	-0.0736	-0.0636	-0.0671	-0.0711
183	Q 6-9	-0.0809	-0.0822	-0.0764	-0.0839	-0.0805	-0.0853	-0.0821
184	Q 6-10	0.0019	NA	0.0042	-0.0007	0.0014	-0.0009	0.0012
185	Q 9-11	-0.1560	-0.1516	-0.1525	-0.1516	-0.1616	-0.1548	-0.1516
186	Q 9-10	0.0588	NA	0.0610	0.0511	0.0545	0.0532	0.0573
187	Q 4-12	0.1441	NA	0.1604	0.1473	0.1597	0.1435	0.1460
188	Q 12-13	-0.1032	-0.1023	-0.1023	-0.1023	-0.1122	-0.1023	-0.1023
189	Q 12-14	0.0240	0.0237	0.0229	0.0236	0.0171	0.0229	0.0237
190	Q 12-15	0.0679	NA	0.0644	0.0654	0.0574	0.0650	0.0672
191	Q 12-16	0.0335	0.0335	0.0283	0.0282	0.0236	0.0318	0.0322
192	Q 14-15	0.0065	0.0063	0.0059	0.0058	0.0090	0.0061	0.0064
193	Q 16-17	0.0144	NA	0.0065	0.0092	0.0107	0.0106	0.0131
194	Q 15-18	0.0160	0.0153	0.0144	0.0154	0.0063	0.0154	0.0153
195	Q 18-19	0.0062	0.0059	0.0042	0.0059	-0.0040	0.0059	0.0059
196	Q 19-20	-0.0279	NA	-0.0301	-0.0290	-0.0289	-0.0290	-0.0279
197	Q 10-20	0.0371	NA	0.0436	0.0438	0.0302	0.0390	0.0382
198	Q 10-17	0.0443	0.0449	0.0465	0.0449	0.0549	0.0449	0.0449
199	Q 10-21	0.1001	NA	0.0978	0.0894	0.0881	0.0931	0.0975
200	Q 10-22	0.0460	NA	0.0449	0.0392	0.0383	0.0421	0.0447
201	Q 21-22	-0.0143	NA	-0.0141	-0.0235	-0.0245	-0.0168	-0.0145
202	Q 15-23	0.0291	NA	0.0257	0.0171	0.0203	0.0260	0.0286
203	Q 22-24	0.0306	0.0295	0.0379	0.0315	0.0395	0.0335	0.0315
204	Q 23-24	0.0124	0.0125	0.0120	0.0125	0.0143	0.0125	0.0114
205	Q 24-25	0.0201	0.0196	0.0316	0.0541	0.0296	0.0267	0.0206
206	Q 25-26	0.0237	0.0233	0.0168	-0.0035	0.0239	0.0154	0.0233
207	Q 25-27	-0.0037	-0.0038	-0.0103	-0.0363	0.0012	-0.0040	-0.0038
208	Q 28-27	0.0504	0.0519	0.0548	0.0478	0.0619	0.0512	0.0489
209	Q 27-29	0.0167	NA	0.0153	0.0130	0.0039	0.0140	0.0176
210	Q 27-30	0.0166	0.0173	0.0161	0.0152	0.0076	0.0156	0.0173
211	Q 29-30	0.0061	0.0060	0.0066	0.0075	0.0056	0.0071	0.0061
212	Q 8-28	-0.0054	NA	0.0113	0.0103	0.0061	-0.0040	-0.0023
213	Q 6-27	0.0011	NA	0.0660	0.0531	0.0477	0.0095	0.0127
214	Q 2-1	0.3447	0.3363	0.2939	0.3442	0.3478	0.3482	0.3449
215	Q 3-1	0.0265	NA	-0.0252	0.0260	0.0192	0.0265	0.0266
216	Q 4-2	-0.0554	NA	-0.1018	-0.0564	-0.0612	-0.0567	-0.0558
217	Q 4-3	0.0544	0.0525	0.0371	0.0519	0.0623	0.0542	0.0527
218	Q 5-2	0.0517	NA	-0.0139	0.0507	0.0560	0.0511	0.0511
219	Q 6-2	0.0058	0.0060	-0.0556	0.0040	0.0021	0.0037	0.0049

220	Q 6-4	0.1719	NA	0.1297	0.1703	0.1810	0.1687	0.1708
221	Q 7-5	-0.1313	NA	-0.0990	-0.1317	-0.1370	-0.1332	-0.1315
222	Q 7-6	0.0223	NA	-0.0275	0.0229	0.0324	0.0228	0.0227
223	Q 8-6	0.0666	NA	0.0556	0.0681	0.0583	0.0615	0.0655
224	Q 9-6	0.0972	NA	0.0923	0.1005	0.0971	0.1017	0.0986
225	Q 10-6	0.0110	NA	0.0085	0.0137	0.0121	0.0137	0.0117
226	Q 11-9	0.1606	NA	0.1568	0.1559	0.1665	0.1593	0.1559
227	Q 10-9	-0.0508	-0.0521	-0.0531	-0.0431	-0.0459	-0.0453	-0.0493
228	Q 12-4	-0.0972	-0.1004	-0.1182	-0.1004	-0.1101	-0.0967	-0.0988
229	Q 13-12	0.1045	NA	0.1036	0.1036	0.1137	0.1036	0.1036
230	Q 14-12	-0.0225	NA	-0.0214	-0.0221	-0.0154	-0.0214	-0.0222
231	Q 15-12	-0.0636	-0.0629	-0.0603	-0.0613	-0.0530	-0.0608	-0.0630
232	Q 16-12	-0.0324	NA	-0.0272	-0.0272	-0.0228	-0.0307	-0.0311
233	Q 15-14	-0.0064	NA	-0.0059	-0.0057	-0.0090	-0.0061	-0.0064
234	Q 17-16	-0.0141	NA	-0.0063	-0.0089	-0.0104	-0.0103	-0.0128
235	Q 18-15	-0.0152	NA	-0.0137	-0.0147	-0.0055	-0.0147	-0.0146
236	Q 19-18	-0.0061	NA	-0.0041	-0.0058	0.0041	-0.0058	-0.0058
237	Q 20-19	0.0283	0.0282	0.0305	0.0293	0.0293	0.0293	0.0282
238	Q 20-10	-0.0353	-0.0363	-0.0417	-0.0419	-0.0281	-0.0372	-0.0363
239	Q 17-10	-0.0439	NA	-0.0461	-0.0445	-0.0544	-0.0445	-0.0445
240	Q 21-10	-0.0977	-0.0957	-0.0954	-0.0871	-0.0856	-0.0908	-0.0952
241	Q 22-10	-0.0449	NA	-0.0438	-0.0382	-0.0372	-0.0411	-0.0436
242	Q 22-21	0.0143	0.0145	0.0141	0.0236	0.0245	0.0168	0.0145
243	Q 23-15	-0.0284	-0.0285	-0.0251	-0.0166	-0.0195	-0.0254	-0.0279
244	Q 24-22	-0.0299	-0.0308	-0.0371	-0.0308	-0.0385	-0.0328	-0.0308
245	Q 24-23	-0.0123	-0.0124	-0.0118	-0.0124	-0.0142	-0.0124	-0.0113
246	Q 25-24	-0.0200	NA	-0.0312	-0.0532	-0.0293	-0.0264	-0.0205
247	Q 26-25	-0.0230	NA	-0.0163	0.0040	-0.0229	-0.0149	-0.0227
248	Q 27-25	0.0042	NA	0.0108	0.0370	-0.0008	0.0044	0.0043
249	Q 27-28	-0.0375	-0.0379	-0.0418	-0.0351	-0.0473	-0.0385	-0.0357
250	Q 29-27	-0.0151	NA	-0.0136	-0.0115	-0.0020	-0.0125	-0.0159
251	Q 30-27	-0.0136	NA	-0.0130	-0.0122	-0.0041	-0.0126	-0.0141
252	Q 30-29	-0.0054	-0.0054	-0.0059	-0.0068	-0.0048	-0.0064	-0.0054
253	Q 28-8	-0.0380	-0.0395	-0.0549	-0.0536	-0.0495	-0.0395	-0.0413
254	Q 28-6	-0.0123	N/A	-0.0771	-0.0642	-0.0579	-0.0207	-0.0240

B.2.5 After Inclusion of PMU Meter Measurements

Table B.9 IEEE 30 Bus System after placing 2 PMUs in SCADA measurement test case

Sr	*Type*	*Actual*	*Measurement*	*Estimated*			
				WLS	*WLAV*	*HLMR*	*ULMR*

1	Vm-1	1.0600	1.0600	1.0600	1.0600	1.0600	1.0608
2	Vm-2	1.0450	1.0450	1.0450	1.0450	1.0451	1.0459
3	Vm-3	1.0212	1.0212	1.0211	1.0212	1.0212	1.0220
4	Vm-4	1.0123	1.0133	1.0123	1.0123	1.0123	1.0132
5	Vm-5	1.0100	1.0176	1.0100	1.0100	1.0101	1.0108
6	Vm-6	1.0106	NA	1.0106	1.0106	1.0105	1.0115
7	Vm-7	1.0026	NA	1.0025	1.0025	1.0026	1.0034
8	Vm-8	1.0100	1.0010	1.0098	1.0101	1.0098	1.0109
9	Vm-9	1.0511	NA	1.0525	1.0523	1.0519	1.0523
10	Vm-10	1.0454	1.0491	1.0475	1.0477	1.0468	1.0467
11	Vm-11	1.0820	NA	1.0833	1.0823	1.0825	1.0822
12	Vm-12	1.0573	1.0557	1.0577	1.0569	1.0575	1.0580
13	Vm-13	1.0710	NA	1.0713	1.0704	1.0710	1.0716
14	Vm-14	1.0425	NA	1.0432	1.0427	1.0430	1.0433
15	Vm-15	1.0379	NA	1.0389	1.0387	1.0386	1.0388
16	Vm-16	1.0446	NA	1.0458	1.0456	1.0452	1.0456
17	Vm-17	1.0402	NA	1.0423	1.0424	1.0415	1.0414
18	Vm-18	1.0284	1.0294	1.0298	1.0294	1.0292	1.0294
19	Vm-19	1.0259	NA	1.0275	1.0270	1.0268	1.0269
20	Vm-20	1.0300	NA	1.0317	1.0312	1.0310	1.0310
21	Vm-21	1.0330	1.0431	1.0357	1.0361	1.0348	1.0345
22	Vm-22	1.0335	NA	1.0363	1.0369	1.0354	1.0351
23	Vm-23	1.0274	NA	1.0291	1.0306	1.0288	1.0285
24	Vm-24	1.0218	1.0252	1.0235	1.0250	1.0232	1.0232
25	Vm-25	1.0176	1.0098	1.0153	1.0098	1.0169	1.0186
26	Vm-26	0.9999	1.0022	1.0009	1.0022	1.0022	1.0015
27	Vm-27	1.0235	NA	1.0219	1.0227	1.0226	1.0246
28	Vm-28	1.0071	1.0052	1.0059	1.0052	1.0066	1.0073
29	Vm-29	1.0037	1.0042	1.0039	1.0042	1.0042	1.0042
30	Vm-30	0.9922	NA	0.9917	0.9922	0.9922	0.9927
31	P-1	2.6096	2.6103	2.6094	2.6096	2.6072	2.6113
32	P-2	0.1830	0.1822	0.1831	0.1830	0.1810	0.1820
33	P-3	-0.0240	NA	-0.0247	-0.0240	-0.0290	-0.0378
34	P-4	-0.0760	-0.0751	-0.0723	-0.0751	-0.0751	-0.0620
35	P-5	-0.9420	-0.9366	-0.9398	-0.9409	-0.9366	-0.9416
36	P-6	0.0000	NA	-0.0051	-0.0026	-0.0009	-0.0003
37	P-7	-0.2280	-0.2306	-0.2329	-0.2306	-0.2306	-0.2306
38	P-8	-0.3000	NA	-0.2969	-0.2959	-0.2960	-0.2960
39	P-9	0.0000	NA	0.0000	0.0000	0.0001	0.0000
40	P-10	-0.0580	-0.0571	-0.0569	-0.0571	-0.0571	-0.0607
41	P-11	0.0000	NA	0.0000	0.0000	0.0000	0.0000
42	P-12	-0.1120	NA	-0.1207	-0.1184	-0.1166	-0.1154

43	P-13	0.0000	NA	0.0000	0.0000	0.0000	0.0000
44	P-14	-0.0620	-0.0613	-0.0620	-0.0613	-0.0613	-0.0619
45	P-15	-0.0820	-0.0813	-0.0808	-0.0813	-0.0813	-0.0813
46	P-16	-0.0350	-0.0349	-0.0359	-0.0349	-0.0349	-0.0368
47	P-17	-0.0900	NA	-0.0876	-0.0887	-0.0890	-0.0887
48	P-18	-0.0320	-0.0322	-0.0317	-0.0322	-0.0322	-0.0316
49	P-19	-0.0950	-0.0944	-0.0949	-0.0952	-0.0949	-0.0967
50	P-20	-0.0220	NA	-0.0222	-0.0215	-0.0214	-0.0215
51	P-21	-0.1750	-0.1780	-0.1767	-0.1777	-0.1760	-0.1748
52	P-22	0.0000	NA	0.0030	-0.0005	0.0003	0.0008
53	P-23	-0.0320	NA	-0.0315	-0.0310	-0.0313	-0.0320
54	P-24	-0.0870	-0.0856	-0.0848	-0.0856	-0.0856	-0.0856
55	P-25	0.0000	NA	-0.0043	-0.0014	-0.0018	-0.0035
56	P-26	-0.0350	NA	-0.0340	-0.0354	-0.0353	-0.0335
57	P-27	0.0000	NA	-0.0004	0.0013	0.0009	-0.0012
58	P-28	0.0000	NA	0.0060	0.0025	0.0014	0.0064
59	P-29	-0.0240	-0.0236	-0.0239	-0.0236	-0.0236	-0.0250
60	P-30	-0.1060	-0.1057	-0.1062	-0.1057	-0.1057	-0.1068
61	Q-1	-0.2042	-0.2064	-0.2040	-0.2042	-0.2060	-0.2056
62	Q-2	0.4337	0.4435	0.4337	0.4337	0.4382	0.4354
63	Q-3	-0.0120	NA	-0.0130	-0.0120	-0.0113	-0.0110
64	Q-4	-0.0160	-0.0154	-0.0153	-0.0139	-0.0152	-0.0154
65	Q-5	0.1666	0.1659	0.1673	0.1666	0.1652	0.1660
66	Q-6	0.0000	NA	0.0126	0.0217	0.0004	0.0095
67	Q-7	-0.1090	-0.1109	-0.1096	-0.1091	-0.1086	-0.1093
68	Q-8	0.0611	NA	0.0611	0.0728	0.0575	0.0634
69	Q-9	0.0000	NA	0.0000	0.0000	0.0001	0.0044
70	Q-10	-0.0200	-0.0207	-0.0191	-0.0207	-0.0206	-0.0211
71	Q-11	0.1606	NA	0.1605	0.1559	0.1593	0.1559
72	Q-12	-0.0750	NA	-0.0796	-0.0938	-0.0792	-0.0775
73	Q-13	0.1045	NA	0.1036	0.1036	0.1036	0.1036
74	Q-14	-0.0160	-0.0163	-0.0153	-0.0163	-0.0153	-0.0158
75	Q-15	-0.0250	-0.0255	-0.0259	-0.0255	-0.0255	-0.0255
76	Q-16	-0.0180	-0.0180	-0.0199	-0.0180	-0.0201	-0.0180
77	Q-17	-0.0580	NA	-0.0528	-0.0520	-0.0549	-0.0573
78	Q-18	-0.0090	-0.0087	-0.0087	-0.0087	-0.0087	-0.0086
79	Q-19	-0.0340	-0.0348	-0.0342	-0.0348	-0.0348	-0.0337
80	Q-20	-0.0070	NA	-0.0075	-0.0110	-0.0078	-0.0081
81	Q-21	-0.1120	-0.1106	-0.1075	-0.1106	-0.1076	-0.1091
82	Q-22	0.0000	NA	0.0118	0.0197	0.0091	0.0026
83	Q-23	-0.0160	NA	-0.0130	-0.0049	-0.0129	-0.0163
84	Q-24	-0.0670	-0.0666	-0.0620	-0.0346	-0.0643	-0.0666

85	Q-25	0.0000	NA	-0.0221	-0.0935	-0.0126	-0.0008
86	Q-26	-0.0230	NA	-0.0149	0.0040	-0.0149	-0.0227
87	Q-27	0.0000	NA	-0.0042	0.0321	-0.0070	0.0040
88	Q-28	0.0000	NA	-0.0238	-0.0460	-0.0090	-0.0171
89	Q-29	-0.0090	NA	-0.0030	-0.0046	-0.0044	-0.0098
90	Q-30	-0.0190	-0.0190	-0.0185	-0.0190	-0.0190	-0.0196
91	P 1-2	1.7331	NA	1.7329	1.7331	1.7307	1.7327
92	P 1-3	0.8765	0.8707	0.8765	0.8765	0.8765	0.8786
93	P 2-4	0.4365	0.4395	0.4365	0.4365	0.4363	0.4360
94	P 3-4	0.8214	NA	0.8208	0.8214	0.8165	0.8096
95	P 2-5	0.8236	0.8199	0.8236	0.8236	0.8207	0.8236
96	P 2-6	0.6038	NA	0.6038	0.6038	0.6026	0.6031
97	P 4-6	0.7213	0.7291	0.7216	0.7213	0.7171	0.7206
98	P 5-7	-0.1478	-0.1474	-0.1457	-0.1467	-0.1451	-0.1474
99	P 6-7	0.3813	0.3870	0.3841	0.3829	0.3812	0.3835
100	P 6-8	0.2956	0.2917	0.2919	0.2917	0.2916	0.2917
101	P 6-9	0.2772	0.2717	0.2781	0.2796	0.2777	0.2792
102	P 6-10	0.1584	0.1596	0.1589	0.1598	0.1587	0.1596
103	P 9-11	0.0000	NA	0.0000	0.0000	0.0000	0.0000
104	P 9-10	0.2772	NA	0.2781	0.2796	0.2777	0.2793
105	P 4-12	0.4419	NA	0.4446	0.4428	0.4420	0.4444
106	P 12-13	0.0000	NA	0.0000	0.0000	0.0000	0.0000
107	P 12-14	0.0786	0.0800	0.0777	0.0772	0.0776	0.0783
108	P 12-15	0.1789	NA	0.1757	0.1765	0.1767	0.1781
109	P 12-16	0.0724	0.0727	0.0704	0.0707	0.0710	0.0727
110	P 14-15	0.0158	0.0156	0.0150	0.0151	0.0155	0.0156
111	P 16-17	0.0369	NA	0.0340	0.0354	0.0356	0.0354
112	P 15-18	0.0602	0.0593	0.0588	0.0593	0.0594	0.0602
113	P 18-19	0.0278	0.0281	0.0267	0.0268	0.0269	0.0282
114	P 19-20	-0.0673	NA	-0.0682	-0.0685	-0.0681	-0.0685
115	P 10-20	0.0903	NA	0.0914	0.0910	0.0904	0.0910
116	P 10-17	0.0533	0.0536	0.0539	0.0536	0.0536	0.0536
117	P 10-21	0.1579	NA	0.1585	0.1604	0.1587	0.1575
118	P 10-22	0.0762	NA	0.0763	0.0773	0.0765	0.0760
119	P 21-22	-0.0183	NA	-0.0193	-0.0184	-0.0184	-0.0184
120	P 15-23	0.0504	NA	0.0491	0.0489	0.0493	0.0500
121	P 22-24	0.0574	0.0580	0.0595	0.0580	0.0580	0.0579
122	P 23-24	0.0180	0.0179	0.0173	0.0177	0.0177	0.0177
123	P 24-25	-0.0121	-0.0118	-0.0086	-0.0104	-0.0104	-0.0106
124	P 25-26	0.0354	0.0357	0.0344	0.0357	0.0357	0.0339
125	P 25-27	-0.0476	-0.0480	-0.0474	-0.0480	-0.0480	-0.0480
126	P 28-27	0.1807	0.1793	0.1810	0.1793	0.1795	0.1842

127	P 27-29	0.0619	NA	0.0619	0.0615	0.0615	0.0630
128	P 27-30	0.0709	0.0722	0.0710	0.0706	0.0706	0.0717
129	P 29-30	0.0370	0.0371	0.0372	0.0371	0.0371	0.0371
130	P 8-28	-0.0054	NA	-0.0060	-0.0053	-0.0054	-0.0054
131	P 6-28	0.1867	NA	0.1816	0.1828	0.1840	0.1838
132	P 2-1	-1.6809	-1.6536	-1.6808	-1.6809	-1.6787	-1.6807
133	P 3-1	-0.8454	NA	-0.8454	-0.8454	-0.8454	-0.8474
134	P 4-2	-0.4263	NA	-0.4263	-0.4263	-0.4262	-0.4258
135	P 4-3	-0.8129	-0.8014	-0.8122	-0.8129	-0.8080	-0.8013
136	P 5-2	-0.7942	NA	-0.7942	-0.7942	-0.7915	-0.7942
137	P 6-2	-0.5843	-0.5796	-0.5844	-0.5843	-0.5832	-0.5837
138	P 6-4	-0.7150	NA	-0.7153	-0.7150	-0.7108	-0.7143
139	P 7-5	0.1495	NA	0.1473	0.1484	0.1468	0.1491
140	P 7-6	-0.3775	NA	-0.3802	-0.3790	-0.3773	-0.3797
141	P 8-6	-0.2946	NA	-0.2909	-0.2906	-0.2906	-0.2906
142	P 9-6	-0.2772	NA	-0.2781	-0.2796	-0.2777	-0.2792
143	P 10-6	-0.1584	NA	-0.1589	-0.1598	-0.1587	-0.1596
144	P 11-9	0.0000	NA	0.0000	0.0000	0.0000	0.0000
145	P 10-9	-0.2772	-0.2796	-0.2781	-0.2796	-0.2777	-0.2793
146	P 12-4	-0.4419	-0.4497	-0.4446	-0.4428	-0.4420	-0.4444
147	P 13-12	0.0000	NA	0.0000	0.0000	0.0000	0.0000
148	P 14-12	-0.0778	NA	-0.0770	-0.0765	-0.0769	-0.0776
149	P 15-12	-0.1767	-0.1733	-0.1737	-0.1745	-0.1746	-0.1759
150	P 16-12	-0.0719	NA	-0.0699	-0.0703	-0.0705	-0.0721
151	P 15-14	-0.0158	NA	-0.0149	-0.0151	-0.0155	-0.0156
152	P 17-16	-0.0368	NA	-0.0339	-0.0353	-0.0356	-0.0353
153	P 18-15	-0.0598	NA	-0.0584	-0.0589	-0.0591	-0.0598
154	P 19-18	-0.0277	NA	-0.0267	-0.0267	-0.0268	-0.0282
155	P 20-19	0.0674	0.0687	0.0684	0.0687	0.0683	0.0687
156	P 20-10	-0.0894	-0.0902	-0.0905	-0.0902	-0.0896	-0.0902
157	P 17-10	-0.0532	NA	-0.0537	-0.0534	-0.0534	-0.0534
158	P 21-10	-0.1567	-0.1564	-0.1574	-0.1593	-0.1576	-0.1564
159	P 22-10	-0.0757	NA	-0.0758	-0.0768	-0.0760	-0.0755
160	P 22-21	0.0183	0.0184	0.0193	0.0184	0.0184	0.0184
161	P 23-15	-0.0500	-0.0507	-0.0488	-0.0487	-0.0490	-0.0497
162	P 24-22	-0.0569	-0.0568	-0.0590	-0.0575	-0.0575	-0.0574
163	P 24-23	-0.0180	-0.0177	-0.0173	-0.0177	-0.0177	-0.0177
164	P 25-24	0.0122	NA	0.0088	0.0110	0.0106	0.0107
165	P 26-25	-0.0350	NA	-0.0340	-0.0354	-0.0353	-0.0335
166	P 27-25	0.0479	NA	0.0477	0.0484	0.0483	0.0483
167	P 27-28	-0.1807	-0.1842	-0.1810	-0.1793	-0.1795	-0.1842
168	P 29-27	-0.0610	NA	-0.0611	-0.0607	-0.0607	-0.0621

169	P 30-27	-0.0693	NA	-0.0694	-0.0690	-0.0690	-0.0700
170	P 30-29	-0.0367	-0.0367	-0.0369	-0.0367	-0.0367	-0.0367
171	P 28-8	0.0055	0.0054	0.0060	0.0054	0.0054	0.0054
172	P 28-6	-0.1862	NA	-0.1810	-0.1822	-0.1834	-0.1832
173	Q 1-2	-0.2470	NA	-0.2470	-0.2470	-0.2490	-0.2483
174	Q 1-3	0.0428	0.0421	0.0430	0.0428	0.0430	0.0428
175	Q 2-4	0.0475	0.0481	0.0475	0.0475	0.0483	0.0476
176	Q 3-4	-0.0385	NA	-0.0394	-0.0385	-0.0377	-0.0379
177	Q 2-5	0.0278	0.0268	0.0276	0.0278	0.0283	0.0282
178	Q 2-6	0.0137	NA	0.0140	0.0137	0.0153	0.0140
179	Q 4-6	-0.1591	-0.1583	-0.1579	-0.1591	-0.1558	-0.1583
180	Q 5-7	0.1149	0.1149	0.1154	0.1149	0.1149	0.1149
181	Q 6-7	-0.0278	-0.0284	-0.0277	-0.0276	-0.0283	-0.0275
182	Q 6-8	-0.0720	-0.0736	-0.0671	-0.0736	-0.0670	-0.0711
183	Q 6-9	-0.0809	-0.0822	-0.0879	-0.0866	-0.0852	-0.0821
184	Q 6-10	0.0019	NA	-0.0022	-0.0023	-0.0009	0.0012
185	Q 9-11	-0.1560	-0.1516	-0.1559	-0.1516	-0.1548	-0.1516
186	Q 9-10	0.0588	NA	0.0514	0.0483	0.0532	0.0573
187	Q 4-12	0.1441	NA	0.1428	0.1462	0.1436	0.1455
188	Q 12-13	-0.1032	-0.1023	-0.1023	-0.1023	-0.1023	-0.1023
189	Q 12-14	0.0240	0.0237	0.0230	0.0219	0.0229	0.0237
190	Q 12-15	0.0679	NA	0.0648	0.0588	0.0650	0.0671
191	Q 12-16	0.0335	0.0335	0.0304	0.0268	0.0318	0.0322
192	Q 14-15	0.0065	0.0063	0.0062	0.0041	0.0061	0.0064
193	Q 16-17	0.0144	NA	0.0095	0.0078	0.0106	0.0130
194	Q 15-18	0.0160	0.0153	0.0146	0.0154	0.0154	0.0153
195	Q 18-19	0.0062	0.0059	0.0051	0.0059	0.0059	0.0059
196	Q 19-20	-0.0279	NA	-0.0292	-0.0290	-0.0290	-0.0279
197	Q 10-20	0.0371	NA	0.0389	0.0422	0.0390	0.0382
198	Q 10-17	0.0443	0.0449	0.0439	0.0449	0.0449	0.0449
199	Q 10-21	0.1001	NA	0.0929	0.0876	0.0931	0.0970
200	Q 10-22	0.0460	NA	0.0420	0.0381	0.0421	0.0444
201	Q 21-22	-0.0143	NA	-0.0169	-0.0253	-0.0168	-0.0145
202	Q 15-23	0.0291	NA	0.0263	0.0179	0.0260	0.0284
203	Q 22-24	0.0306	0.0295	0.0358	0.0315	0.0334	0.0315
204	Q 23-24	0.0124	0.0125	0.0128	0.0125	0.0125	0.0114
205	Q 24-25	0.0201	0.0196	0.0306	0.0537	0.0258	0.0205
206	Q 25-26	0.0237	0.0233	0.0154	-0.0035	0.0154	0.0233
207	Q 25-27	-0.0037	-0.0038	-0.0072	-0.0371	-0.0025	-0.0038
208	Q 28-27	0.0504	0.0519	0.0516	0.0473	0.0512	0.0485
209	Q 27-29	0.0167	NA	0.0121	0.0135	0.0133	0.0176
210	Q 27-30	0.0166	0.0173	0.0146	0.0154	0.0153	0.0173

211	Q 29-30	0.0061	0.0060	0.0075	0.0073	0.0074	0.0061
212	Q 8-28	-0.0054	NA	-0.0005	0.0047	-0.0040	-0.0022
213	Q 6-27	0.0011	NA	0.0212	0.0341	0.0095	0.0130
214	Q 2-1	0.3447	0.3363	0.3446	0.3447	0.3462	0.3456
215	Q 3-1	0.0265	NA	0.0264	0.0265	0.0264	0.0269
216	Q 4-2	-0.0554	NA	-0.0554	-0.0554	-0.0563	-0.0557
217	Q 4-3	0.0544	0.0525	0.0552	0.0544	0.0533	0.0531
218	Q 5-2	0.0517	NA	0.0519	0.0517	0.0503	0.0511
219	Q 6-2	0.0058	0.0060	0.0056	0.0058	0.0040	0.0052
220	Q 6-4	0.1719	NA	0.1707	0.1719	0.1683	0.1709
221	Q 7-5	-0.1313	NA	-0.1319	-0.1313	-0.1314	-0.1314
222	Q 7-6	0.0223	NA	0.0223	0.0222	0.0228	0.0221
223	Q 8-6	0.0666	NA	0.0615	0.0681	0.0615	0.0656
224	Q 9-6	0.0972	NA	0.1045	0.1033	0.1017	0.0986
225	Q 10-6	0.0110	NA	0.0151	0.0154	0.0137	0.0118
226	Q 11-9	0.1606	NA	0.1605	0.1559	0.1593	0.1559
227	Q 10-9	-0.0508	-0.0521	-0.0435	-0.0403	-0.0453	-0.0493
228	Q 12-4	-0.0972	-0.1004	-0.0955	-0.0990	-0.0967	-0.0982
229	Q 13-12	0.1045	NA	0.1036	0.1036	0.1036	0.1036
230	Q 14-12	-0.0225	NA	-0.0215	-0.0204	-0.0214	-0.0222
231	Q 15-12	-0.0636	-0.0629	-0.0607	-0.0547	-0.0608	-0.0629
232	Q 16-12	-0.0324	NA	-0.0294	-0.0258	-0.0307	-0.0311
233	Q 15-14	-0.0064	NA	-0.0061	-0.0041	-0.0061	-0.0063
234	Q 17-16	-0.0141	NA	-0.0093	-0.0075	-0.0104	-0.0128
235	Q 18-15	-0.0152	NA	-0.0138	-0.0147	-0.0147	-0.0146
236	Q 19-18	-0.0061	NA	-0.0050	-0.0058	-0.0058	-0.0058
237	Q 20-19	0.0283	0.0282	0.0296	0.0293	0.0293	0.0282
238	Q 20-10	-0.0353	-0.0363	-0.0371	-0.0403	-0.0371	-0.0363
239	Q 17-10	-0.0439	NA	-0.0435	-0.0445	-0.0445	-0.0445
240	Q 21-10	-0.0977	-0.0957	-0.0906	-0.0854	-0.0908	-0.0947
241	Q 22-10	-0.0449	NA	-0.0410	-0.0370	-0.0411	-0.0434
242	Q 22-21	0.0143	0.0145	0.0169	0.0253	0.0168	0.0145
243	Q 23-15	-0.0284	-0.0285	-0.0258	-0.0174	-0.0254	-0.0277
244	Q 24-22	-0.0299	-0.0308	-0.0350	-0.0308	-0.0327	-0.0308
245	Q 24-23	-0.0123	-0.0124	-0.0126	-0.0124	-0.0124	-0.0113
246	Q 25-24	-0.0200	NA	-0.0303	-0.0528	-0.0256	-0.0203
247	Q 26-25	-0.0230	NA	-0.0149	0.0040	-0.0149	-0.0227
248	Q 27-25	0.0042	NA	0.0076	0.0379	0.0029	0.0043
249	Q 27-28	-0.0375	-0.0379	-0.0386	-0.0347	-0.0385	-0.0352
250	Q 29-27	-0.0151	NA	-0.0105	-0.0119	-0.0117	-0.0159
251	Q 30-27	-0.0136	NA	-0.0116	-0.0124	-0.0123	-0.0142
252	Q 30-29	-0.0054	-0.0054	-0.0069	-0.0066	-0.0067	-0.0054

253	Q 28-8	-0.0380	-0.0395	-0.0429	-0.0480	-0.0395	-0.0413
254	Q 28-6	-0.0123	N/A	-0.0325	-0.0453	-0.0208	-0.0242

B.3 Detail Estimation Results of 118-Bus System

B.3.1 White Noise Mixed Measurements

Table B.10 IEEE 118 Bus System with white noise mixed SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	Vm-1	0.9550	NA	0.9539	0.9526	0.9568	0.9540	0.9570
2	Vm-2	0.9714	0.9687	0.9699	0.9687	0.9729	0.9701	0.9730
3	Vm-3	0.9677	0.9694	0.9669	0.9655	0.9696	0.9669	0.9698
4	Vm-4	0.9980	0.9888	0.9976	0.9963	1.0003	0.9976	1.0004
5	Vm-5	1.0020	0.9945	1.0017	1.0004	1.0043	1.0017	1.0044
6	Vm-6	0.9900	NA	0.9894	0.9883	0.9921	0.9895	0.9922
7	Vm-7	0.9893	NA	0.9887	0.9877	0.9914	0.9889	0.9915
8	Vm-8	1.0150	NA	1.0153	1.0160	1.0173	1.0153	1.0171
9	Vm-9	1.0429	1.0463	1.0436	1.0463	1.0453	1.0436	1.0452
10	Vm-10	1.0500	NA	1.0509	1.0555	1.0522	1.0508	1.0520
11	Vm-11	0.9851	NA	0.9847	0.9835	0.9875	0.9848	0.9876
12	Vm-12	0.9900	0.9828	0.9894	0.9884	0.9922	0.9896	0.9922
13	Vm-13	0.9683	NA	0.9677	0.9671	0.9703	0.9678	0.9703
14	Vm-14	0.9836	NA	0.9827	0.9820	0.9850	0.9829	0.9847
15	Vm-15	0.9700	0.9703	0.9696	0.9709	0.9711	0.9696	0.9709
16	Vm-16	0.9839	NA	0.9830	0.9829	0.9854	0.9830	0.9854
17	Vm-17	0.9951	1.0000	0.9945	0.9959	0.9958	0.9944	0.9955
18	Vm-18	0.9730	0.9768	0.9728	0.9742	0.9741	0.9727	0.9738
19	Vm-19	0.9620	NA	0.9619	0.9633	0.9630	0.9618	0.9628
20	Vm-20	0.9569	NA	0.9583	0.9591	0.9584	0.9583	0.9582
21	Vm-21	0.9577	0.9604	0.9598	0.9604	0.9594	0.9598	0.9592
22	Vm-22	0.9690	NA	0.9712	0.9718	0.9709	0.9711	0.9706
23	Vm-23	0.9995	1.0001	1.0015	1.0009	1.0010	1.0011	1.0005
24	Vm-24	0.9920	0.9873	0.9938	0.9933	0.9935	0.9936	0.9930
25	Vm-25	1.0500	1.0536	1.0522	1.0536	1.0525	1.0521	1.0521
26	Vm-26	1.0150	NA	1.0168	1.0186	1.0176	1.0167	1.0172
27	Vm-27	0.9680	0.9732	0.9701	0.9725	0.9694	0.9699	0.9690
28	Vm-28	0.9616	0.9598	0.9632	0.9647	0.9628	0.9629	0.9625

29	Vm-29	0.9632	0.9696	0.9647	0.9662	0.9642	0.9645	0.9640
30	Vm-30	0.9853	0.9891	0.9859	0.9871	0.9870	0.9858	0.9868
31	Vm-31	0.9670	NA	0.9683	0.9700	0.9680	0.9681	0.9678
32	Vm-32	0.9630	NA	0.9650	0.9674	0.9644	0.9648	0.9639
33	Vm-33	0.9709	NA	0.9719	0.9742	0.9729	0.9717	0.9725
34	Vm-34	0.9840	0.9922	0.9864	0.9903	0.9866	0.9862	0.9865
35	Vm-35	0.9805	NA	0.9828	0.9866	0.9831	0.9826	0.9830
36	Vm-36	0.9800	0.9866	0.9824	0.9862	0.9826	0.9822	0.9825
37	Vm-37	0.9907	0.9967	0.9928	0.9967	0.9932	0.9926	0.9930
38	Vm-38	0.9613	NA	0.9625	0.9641	0.9633	0.9624	0.9630
39	Vm-39	0.9700	NA	0.9718	0.9745	0.9728	0.9721	0.9726
40	Vm-40	0.9700	0.9747	0.9720	0.9747	0.9729	0.9723	0.9728
41	Vm-41	0.9668	NA	0.9687	0.9715	0.9697	0.9692	0.9696
42	Vm-42	0.9850	0.9796	0.9862	0.9876	0.9873	0.9866	0.9872
43	Vm-43	0.9771	NA	0.9779	0.9672	0.9796	0.9777	0.9796
44	Vm-44	0.9844	0.9748	0.9844	0.9748	0.9867	0.9844	0.9865
45	Vm-45	0.9864	0.9905	0.9868	0.9896	0.9884	0.9868	0.9881
46	Vm-46	1.0050	1.0054	1.0053	1.0054	1.0064	1.0053	1.0060
47	Vm-47	1.0171	NA	1.0172	1.0162	1.0182	1.0173	1.0179
48	Vm-48	1.0206	NA	1.0208	1.0191	1.0216	1.0210	1.0213
49	Vm-49	1.0250	1.0334	1.0250	1.0235	1.0260	1.0251	1.0257
50	Vm-50	1.0011	NA	1.0013	0.9999	1.0025	1.0015	1.0020
51	Vm-51	0.9669	0.9762	0.9673	0.9642	0.9680	0.9675	0.9678
52	Vm-52	0.9568	NA	0.9570	0.9538	0.9579	0.9572	0.9576
53	Vm-53	0.9460	0.9407	0.9454	0.9419	0.9471	0.9458	0.9468
54	Vm-54	0.9550	0.9515	0.9545	0.9521	0.9561	0.9546	0.9559
55	Vm-55	0.9520	NA	0.9514	0.9490	0.9530	0.9515	0.9528
56	Vm-56	0.9540	0.9511	0.9534	0.9511	0.9550	0.9536	0.9549
57	Vm-57	0.9706	0.9646	0.9699	0.9646	0.9719	0.9700	0.9716
58	Vm-58	0.9590	NA	0.9591	0.9564	0.9601	0.9593	0.9599
59	Vm-59	0.9850	0.9915	0.9848	0.9822	0.9860	0.9847	0.9856
60	Vm-60	0.9932	NA	0.9929	0.9903	0.9943	0.9929	0.9939
61	Vm-61	0.9950	NA	0.9947	0.9921	0.9961	0.9947	0.9958
62	Vm-62	0.9980	0.9923	0.9974	0.9945	0.9986	0.9972	0.9984
63	Vm-63	0.9687	0.9648	0.9686	0.9660	0.9698	0.9685	0.9694
64	Vm-64	0.9837	0.9782	0.9836	0.9810	0.9848	0.9836	0.9845
65	Vm-65	1.0050	NA	1.0050	1.0027	1.0063	1.0051	1.0060
66	Vm-66	1.0500	NA	1.0501	1.0478	1.0511	1.0501	1.0509
67	Vm-67	1.0197	NA	1.0197	1.0168	1.0205	1.0195	1.0204
68	Vm-68	1.0032	0.9981	1.0035	1.0021	1.0045	1.0035	1.0043
69	Vm-69	1.0350	1.0435	1.0361	1.0349	1.0368	1.0361	1.0367
70	Vm-70	0.9840	0.9887	0.9851	0.9849	0.9856	0.9854	0.9852

71	Vm-71	0.9868	0.9886	0.9884	0.9889	0.9885	0.9886	0.9881
72	Vm-72	0.9800	NA	0.9823	0.9818	0.9818	0.9821	0.9812
73	Vm-73	0.9910	0.9973	0.9930	0.9945	0.9927	0.9932	0.9922
74	Vm-74	0.9580	NA	0.9580	0.9571	0.9592	0.9587	0.9590
75	Vm-75	0.9673	0.9578	0.9671	0.9663	0.9684	0.9679	0.9681
76	Vm-76	0.9430	0.9415	0.9427	0.9415	0.9438	0.9431	0.9435
77	Vm-77	1.0060	1.0122	1.0072	1.0076	1.0080	1.0074	1.0079
78	Vm-78	1.0034	NA	1.0050	1.0056	1.0057	1.0051	1.0055
79	Vm-79	1.0092	NA	1.0108	1.0113	1.0115	1.0108	1.0113
80	Vm-80	1.0400	1.0495	1.0410	1.0418	1.0418	1.0411	1.0418
81	Vm-81	0.9968	NA	0.9973	0.9967	0.9982	0.9974	0.9979
82	Vm-82	0.9885	0.9897	0.9894	0.9897	0.9905	0.9899	0.9904
83	Vm-83	0.9844	NA	0.9851	0.9856	0.9864	0.9856	0.9863
84	Vm-84	0.9797	NA	0.9794	0.9811	0.9815	0.9807	0.9818
85	Vm-85	0.9850	0.9763	0.9848	0.9860	0.9870	0.9860	0.9869
86	Vm-86	0.9867	0.9875	0.9865	0.9875	0.9886	0.9875	0.9884
87	Vm-87	1.0150	NA	1.0151	1.0160	1.0173	1.0160	1.0169
88	Vm-88	0.9875	NA	0.9871	0.9885	0.9896	0.9886	0.9895
89	Vm-89	1.0050	NA	1.0049	1.0059	1.0071	1.0061	1.0069
90	Vm-90	0.9850	NA	0.9850	0.9861	0.9871	0.9860	0.9868
91	Vm-91	0.9800	0.9868	0.9806	0.9813	0.9820	0.9811	0.9818
92	Vm-92	0.9900	0.9806	0.9901	0.9908	0.9921	0.9912	0.9919
93	Vm-93	0.9854	NA	0.9850	0.9861	0.9873	0.9865	0.9872
94	Vm-94	0.9898	0.9921	0.9911	0.9912	0.9919	0.9911	0.9917
95	Vm-95	0.9803	NA	0.9813	0.9816	0.9822	0.9814	0.9820
96	Vm-96	0.9923	NA	0.9933	0.9937	0.9943	0.9935	0.9941
97	Vm-97	1.0112	NA	1.0122	1.0126	1.0130	1.0122	1.0128
98	Vm-98	1.0235	NA	1.0244	1.0254	1.0250	1.0245	1.0249
99	Vm-99	1.0100	NA	1.0112	1.0127	1.0118	1.0114	1.0117
100	Vm-100	1.0170	1.0221	1.0179	1.0195	1.0184	1.0180	1.0182
101	Vm-101	0.9914	0.9859	0.9909	0.9873	0.9927	0.9927	0.9923
102	Vm-102	0.9891	0.9915	0.9889	0.9883	0.9909	0.9902	0.9907
103	Vm-103	1.0100	1.0141	1.0110	1.0123	1.0112	1.0110	1.0109
104	Vm-104	0.9710	NA	0.9726	0.9731	0.9727	0.9723	0.9722
105	Vm-105	0.9650	0.9742	0.9666	0.9668	0.9667	0.9663	0.9662
106	Vm-106	0.9611	NA	0.9630	0.9630	0.9630	0.9627	0.9627
107	Vm-107	0.9520	0.9527	0.9538	0.9527	0.9540	0.9535	0.9535
108	Vm-108	0.9662	NA	0.9675	0.9677	0.9676	0.9673	0.9672
109	Vm-109	0.9670	NA	0.9684	0.9686	0.9685	0.9682	0.9681
110	Vm-110	0.9730	0.9825	0.9742	0.9736	0.9748	0.9742	0.9745
111	Vm-111	0.9800	0.9782	0.9810	0.9782	0.9816	0.9811	0.9814
112	Vm-112	0.9750	0.9667	0.9757	0.9756	0.9767	0.9757	0.9765

113	Vm-113	0.9930	0.9858	0.9924	0.9939	0.9938	0.9922	0.9935
114	Vm-114	0.9601	0.9645	0.9622	0.9645	0.9615	0.9619	0.9610
115	Vm-115	0.9600	NA	0.9621	0.9645	0.9614	0.9618	0.9609
116	Vm-116	1.0050	NA	1.0051	1.0037	1.0062	1.0052	1.0059
117	Vm-117	0.9738	NA	0.9729	0.9721	0.9760	0.9733	0.9760
118	Vm-118	0.9494	NA	0.9491	0.9481	0.9503	0.9497	0.9500
119	PG-1	-0.5100	NA	-0.5138	-0.5192	-0.5168	-0.5189	-0.5196
120	PG-2	-0.2000	NA	-0.2074	-0.2052	-0.2052	-0.2052	-0.2052
121	PG-3	-0.3900	-0.3849	-0.3837	-0.3849	-0.3839	-0.3849	-0.3834
122	PG-4	-0.3900	-0.3958	-0.3959	-0.3958	-0.3948	-0.3958	-0.3943
123	PG-5	0.0000	NA	0.0153	0.0330	0.0014	0.0160	-0.0011
124	PG-6	-0.5200	NA	-0.5094	-0.5150	-0.5104	-0.5119	-0.5120
125	PG-7	-0.1900	NA	-0.1987	-0.1991	-0.1991	-0.1968	-0.1991
126	PG-8	-0.2800	-0.2824	-0.2824	-0.2824	-0.2814	-0.2824	-0.2824
127	PG-9	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
128	PG-10	4.5000	NA	4.4831	4.4834	4.4826	4.4838	4.4837
129	PG-11	-0.7000	NA	-0.7036	-0.6996	-0.6976	-0.7038	-0.6956
130	PG-12	0.3800	0.3848	0.3839	0.3848	0.3858	0.3848	0.3842
131	PG-13	-0.3400	-0.3381	-0.3387	-0.3381	-0.3381	-0.3381	-0.3381
132	PG-14	-0.1400	NA	-0.1449	-0.1430	-0.1427	-0.1439	-0.1418
133	PG-15	-0.9000	-0.8950	-0.8986	-0.8968	-0.8960	-0.8953	-0.8950
134	PG-16	-0.2500	-0.2480	-0.2486	-0.2480	-0.2488	-0.2480	-0.2480
135	PG-17	-0.1100	NA	-0.0575	-0.0845	-0.0987	-0.0647	-0.0935
136	PG-18	-0.6000	NA	-0.6023	-0.6016	-0.6044	-0.6014	-0.6058
137	PG-19	-0.4500	-0.4509	-0.4530	-0.4509	-0.4519	-0.4509	-0.4509
138	PG-20	-0.1800	-0.1776	-0.1807	-0.1776	-0.1786	-0.1807	-0.1776
139	PG-21	-0.1400	NA	-0.1399	-0.1416	-0.1446	-0.1411	-0.1450
140	PG-22	-0.1000	NA	-0.0904	-0.0862	-0.0851	-0.0918	-0.0847
141	PG-23	-0.0700	NA	-0.1078	-0.0954	-0.0988	-0.1104	-0.1034
142	PG-24	-0.1300	-0.1323	-0.1337	-0.1323	-0.1313	-0.1323	-0.1308
143	PG-25	2.2000	2.2435	2.2400	2.2435	2.2439	2.2470	2.2435
144	PG-26	3.1400	NA	3.1183	3.1559	3.1617	3.1234	3.1606
145	PG-27	-0.7100	NA	-0.7097	-0.7192	-0.7171	-0.7105	-0.7167
146	PG-28	-0.1700	NA	-0.1744	-0.1738	-0.1752	-0.1770	-0.1738
147	PG-29	-0.2400	NA	-0.2356	-0.2378	-0.2382	-0.2369	-0.2382
148	PG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
149	PG-31	-0.3600	-0.3664	-0.3644	-0.3664	-0.3654	-0.3664	-0.3649
150	PG-32	-0.5900	NA	-0.6068	-0.6014	-0.5939	-0.6037	-0.5951
151	PG-33	-0.2300	-0.2314	-0.2328	-0.2386	-0.2324	-0.2319	-0.2314
152	PG-34	-0.5900	NA	-0.6124	-0.6017	-0.6129	-0.5973	-0.5980
153	PG-35	-0.3300	-0.3295	-0.3303	-0.3295	-0.3305	-0.3295	-0.3295
154	PG-36	-0.3100	-0.3044	-0.3051	-0.3044	-0.3054	-0.3044	-0.3044

155	PG-37	0.0000	NA	-0.0045	-0.0782	-0.0183	-0.0205	-0.0333
156	PG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
157	PG-39	-0.2700	NA	-0.2630	-0.2549	-0.2559	-0.2632	-0.2609
158	PG-40	-0.6600	NA	-0.6516	-0.6478	-0.6483	-0.6519	-0.6511
159	PG-41	-0.3700	NA	-0.3693	-0.3677	-0.3687	-0.3676	-0.3683
160	PG-42	-0.9600	-0.9690	-0.9675	-0.9690	-0.9680	-0.9690	-0.9690
161	PG-43	-0.1800	NA	-0.1810	-0.1788	-0.1794	-0.1805	-0.1805
162	PG-44	-0.1600	-0.1581	-0.1594	-0.1581	-0.1591	-0.1582	-0.1581
163	PG-45	-0.5300	NA	-0.5209	-0.5330	-0.5298	-0.5253	-0.5325
164	PG-46	-0.0900	-0.0884	-0.0907	-0.0884	-0.0894	-0.0907	-0.0899
165	PG-47	-0.3400	-0.3455	-0.3434	-0.3455	-0.3445	-0.3455	-0.3440
166	PG-48	-0.2000	NA	-0.2025	-0.2004	-0.2014	-0.2008	-0.1998
167	PG-49	1.1700	1.1639	1.1634	1.1639	1.1629	1.1639	1.1624
168	PG-50	-0.1700	NA	-0.1563	-0.1474	-0.1512	-0.1504	-0.1534
169	PG-51	-0.1700	NA	-0.1764	-0.1739	-0.1746	-0.1730	-0.1704
170	PG-52	-0.1800	-0.1806	-0.1819	-0.1826	-0.1816	-0.1831	-0.1822
171	PG-53	-0.2300	-0.2321	-0.2327	-0.2321	-0.2331	-0.2321	-0.2336
172	PG-54	-0.6500	-0.6479	-0.6472	-0.6479	-0.6489	-0.6486	-0.6492
173	PG-55	-0.6300	-0.6404	-0.6379	-0.6404	-0.6394	-0.6404	-0.6389
174	PG-56	-0.8400	NA	-0.8287	-0.8205	-0.8336	-0.8290	-0.8326
175	PG-57	-0.1200	NA	-0.1295	-0.1376	-0.1342	-0.1323	-0.1340
176	PG-58	-0.1200	NA	-0.1220	-0.1215	-0.1215	-0.1220	-0.1220
177	PG-59	-1.2200	NA	-1.2311	-1.2570	-1.2173	-1.2304	-1.2119
178	PG-60	-0.7800	NA	-0.7590	-0.7776	-0.7403	-0.7588	-0.7434
179	PG-61	1.6000	1.5911	1.5827	1.5911	1.5901	1.5827	1.5896
180	PG-62	-0.7700	NA	-0.7963	-0.7707	-0.8037	-0.7963	-0.7971
181	PG-63	0.0000	NA	0.0000	0.0000	-0.0181	0.0000	-0.0216
182	PG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
183	PG-65	3.9100	NA	3.9402	3.9723	3.9442	3.9362	3.9391
184	PG-66	3.5300	3.5670	3.5603	3.5670	3.5660	3.5603	3.5655
185	PG-67	-0.2800	NA	-0.2856	-0.3030	-0.3012	-0.2856	-0.3013
186	PG-68	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
187	PG-69	5.1386	NA	5.1310	5.1264	5.1210	5.1274	5.1226
188	PG-70	-0.6600	-0.6498	-0.6507	-0.6498	-0.6508	-0.6498	-0.6513
189	PG-71	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
190	PG-72	-0.1200	NA	-0.1240	-0.1249	-0.1214	-0.1247	-0.1210
191	PG-73	-0.0600	NA	-0.0603	-0.0591	-0.0601	-0.0591	-0.0591
192	PG-74	-0.6800	NA	-0.6734	-0.6746	-0.6735	-0.6734	-0.6751
193	PG-75	-0.4700	NA	-0.4860	-0.4834	-0.4845	-0.4843	-0.4853
194	PG-76	-0.6800	NA	-0.6806	-0.6848	-0.6798	-0.6816	-0.6791
195	PG-77	-0.6100	-0.6014	-0.6011	-0.6014	-0.6004	-0.6014	-0.5999
196	PG-78	-0.7100	NA	-0.7269	-0.7190	-0.7256	-0.7249	-0.7271

197	PG-79	-0.3900	-0.3952	-0.3960	-0.3952	-0.3962	-0.3952	-0.3951
198	PG-80	3.4700	NA	3.5014	3.5024	3.4956	3.5006	3.4988
199	PG-81	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
200	PG-82	-0.5400	NA	-0.5428	-0.5489	-0.5467	-0.5435	-0.5491
201	PG-83	-0.2000	-0.2017	-0.1982	-0.2017	-0.2007	-0.1982	-0.2002
202	PG-84	-0.1100	NA	-0.1091	-0.0891	-0.1112	-0.1088	-0.0994
203	PG-85	-0.2400	-0.2384	-0.2348	-0.2384	-0.2374	-0.2348	-0.2369
204	PG-86	-0.2100	-0.2101	-0.2093	-0.2101	-0.2111	-0.2101	-0.2114
205	PG-87	0.0400	NA	0.0402	0.0398	0.0401	0.0398	0.0398
206	PG-88	-0.4800	NA	-0.4896	-0.4935	-0.4819	-0.4882	-0.4880
207	PG-89	6.0700	NA	6.0799	6.0620	6.0978	6.0763	6.0782
208	PG-90	-1.6300	-1.6414	-1.6428	-1.6414	-1.6424	-1.6414	-1.6429
209	PG-91	-0.1000	NA	-0.0966	-0.0909	-0.0969	-0.0997	-0.0944
210	PG-92	-0.6500	-0.6440	-0.6454	-0.6440	-0.6450	-0.6440	-0.6455
211	PG-93	-0.1200	NA	-0.1135	-0.1106	-0.0989	-0.1096	-0.1059
212	PG-94	-0.3000	NA	-0.3018	-0.3041	-0.3225	-0.3054	-0.3123
213	PG-95	-0.4200	NA	-0.4251	-0.4286	-0.4257	-0.4278	-0.4251
214	PG-96	-0.3800	-0.3754	-0.3769	-0.3754	-0.3764	-0.3754	-0.3769
215	PG-97	-0.1500	-0.1484	-0.1495	-0.1484	-0.1494	-0.1484	-0.1499
216	PG-98	-0.3400	-0.3426	-0.3398	-0.3426	-0.3416	-0.3398	-0.3411
217	PG-99	-0.4200	-0.4243	-0.4213	-0.4243	-0.4233	-0.4243	-0.4243
218	PG-100	2.1500	NA	2.1305	2.1360	2.1301	2.1374	2.1370
219	PG-101	-0.2200	NA	-0.2175	-0.2147	-0.2210	-0.2177	-0.2179
220	PG-102	-0.0500	-0.0491	-0.0506	-0.0491	-0.0501	-0.0491	-0.0506
221	PG-103	0.1700	NA	0.1624	0.1669	0.1671	0.1658	0.1659
222	PG-104	-0.3800	-0.3732	-0.3713	-0.3732	-0.3722	-0.3713	-0.3717
223	PG-105	-0.3100	-0.3093	-0.3087	-0.3093	-0.3095	-0.3093	-0.3093
224	PG-106	-0.4300	NA	-0.4214	-0.4250	-0.4244	-0.4250	-0.4251
225	PG-107	-0.5000	NA	-0.5010	-0.5025	-0.5002	-0.5025	-0.5024
226	PG-108	-0.0200	NA	-0.0225	-0.0224	-0.0227	-0.0224	-0.0224
227	PG-109	-0.0800	NA	-0.0741	-0.0736	-0.0754	-0.0743	-0.0758
228	PG-110	-0.3900	-0.3969	-0.3960	-0.3969	-0.3959	-0.3969	-0.3954
229	PG-111	0.3600	0.3566	0.3573	0.3566	0.3568	0.3566	0.3566
230	PG-112	-0.6800	-0.6720	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
231	PG-113	-0.0600	NA	-0.0526	-0.0573	-0.0596	-0.0512	-0.0580
232	PG-114	-0.0800	NA	-0.0793	-0.0797	-0.0797	-0.0797	-0.0797
233	PG-115	-0.2200	NA	-0.2236	-0.2234	-0.2234	-0.2234	-0.2219
234	PG-116	-1.8400	-1.8683	-1.8444	-1.8291	-1.8321	-1.8444	-1.8310
235	PG-117	-0.2000	-0.1997	-0.1996	-0.1997	-0.1996	-0.1996	-0.1986
236	PG-118	-0.3300	-0.3321	-0.3291	-0.3321	-0.3311	-0.3291	-0.3306
237	QG-1	-0.3010	NA	-0.3004	-0.3002	-0.3005	-0.2995	-0.2967
238	QG-2	-0.0900	NA	-0.1058	-0.1085	-0.1030	-0.1058	-0.1019

239	QG-3	-0.1000	-0.1028	-0.1029	-0.1028	-0.1038	-0.1028	-0.1048
240	QG-4	-0.2701	-0.2755	-0.2765	-0.2755	-0.2745	-0.2745	-0.2735
241	QG-5	0.0000	NA	-0.0087	-0.0915	0.0126	-0.0152	0.0162
242	QG-6	-0.0607	NA	-0.0668	-0.0624	-0.0668	-0.0654	-0.0676
243	QG-7	-0.0200	NA	-0.0235	-0.0197	-0.0217	-0.0197	-0.0197
244	QG-8	0.6314	0.6283	0.6372	0.6283	0.6293	0.6372	0.6283
245	QG-9	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
246	QG-10	-0.5104	NA	-0.5073	-0.4525	-0.5224	-0.5070	-0.5224
247	QG-11	-0.2300	NA	-0.2168	-0.2332	-0.2121	-0.2173	-0.2100
248	QG-12	0.8129	0.8385	0.8341	0.8289	0.8375	0.8341	0.8385
249	QG-13	-0.1600	-0.1639	-0.1647	-0.1639	-0.1629	-0.1646	-0.1639
250	QG-14	-0.0100	NA	-0.0160	-0.0217	-0.0194	-0.0152	-0.0244
251	QG-15	-0.2284	-0.2335	-0.2364	-0.2335	-0.2325	-0.2335	-0.2305
252	QG-16	-0.1000	-0.1035	-0.1065	-0.1035	-0.1045	-0.1065	-0.1035
253	QG-17	-0.0300	NA	-0.0929	-0.0781	-0.0815	-0.0849	-0.0870
254	QG-18	-0.0557	NA	-0.0475	-0.0513	-0.0473	-0.0511	-0.0472
255	QG-19	-0.3927	-0.4078	-0.4073	-0.4078	-0.4068	-0.4078	-0.4058
256	QG-20	-0.0300	-0.0301	-0.0258	-0.0301	-0.0291	-0.0258	-0.0281
257	QG-21	-0.0800	NA	-0.0733	-0.0747	-0.0779	-0.0720	-0.0789
258	QG-22	-0.0500	NA	-0.0510	-0.0444	-0.0501	-0.0495	-0.0492
259	QG-23	-0.0300	NA	-0.0216	-0.0832	-0.0357	-0.0317	-0.0350
260	QG-24	-0.1491	-0.1525	-0.1543	-0.1525	-0.1517	-0.1525	-0.1525
261	QG-25	0.5004	0.5166	0.5106	0.5166	0.5156	0.5166	0.5146
262	QG-26	0.1012	NA	0.1036	0.1263	0.1160	0.1049	0.1155
263	QG-27	-0.0902	NA	-0.0848	-0.0637	-0.0925	-0.0824	-0.0904
264	QG-28	-0.0700	NA	-0.0724	-0.0832	-0.0683	-0.0734	-0.0683
265	QG-29	-0.0400	NA	-0.0399	-0.0431	-0.0449	-0.0375	-0.0429
266	QG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	0.0004
267	QG-31	0.0559	0.0579	0.0587	0.0579	0.0569	0.0579	0.0593
268	QG-32	-0.3928	NA	-0.3731	-0.3380	-0.3845	-0.3725	-0.3919
269	QG-33	-0.0900	-0.0883	-0.0870	-0.0883	-0.0873	-0.0883	-0.0903
270	QG-34	-0.4683	NA	-0.4121	-0.3162	-0.4461	-0.4216	-0.4426
271	QG-35	-0.0900	-0.0909	-0.0893	-0.0909	-0.0899	-0.0909	-0.0889
272	QG-36	-0.0927	-0.0959	-0.0936	-0.0959	-0.0949	-0.0932	-0.0934
273	QG-37	0.0000	NA	0.0008	0.0942	0.0039	0.0010	-0.0009
274	QG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
275	QG-39	-0.1100	NA	-0.1181	-0.1328	-0.1141	-0.1134	-0.1137
276	QG-40	0.0545	NA	0.0595	0.0544	0.0574	0.0601	0.0591
277	QG-41	-0.1000	NA	-0.0983	-0.0870	-0.0990	-0.0962	-0.0971
278	QG-42	0.1803	0.1818	0.1806	0.1818	0.1828	0.1818	0.1838
279	QG-43	-0.0700	NA	-0.0761	-0.1630	-0.0710	-0.0773	-0.0693
280	QG-44	-0.0800	-0.0780	-0.0875	-0.2171	-0.0790	-0.0875	-0.0780

281	QG-45	-0.2200	NA	-0.2165	-0.0334	-0.2136	-0.2157	-0.2141
282	QG-46	-0.1503	-0.1522	-0.1497	-0.1522	-0.1524	-0.1497	-0.1522
283	QG-47	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
284	QG-48	-0.1100	NA	-0.1051	-0.1200	-0.1117	-0.1050	-0.1129
285	QG-49	0.8585	0.8283	0.8337	0.8283	0.8293	0.8337	0.8283
286	QG-50	-0.0400	NA	-0.0344	-0.0084	-0.0404	-0.0352	-0.0420
287	QG-51	-0.0800	NA	-0.0639	-0.0787	-0.0762	-0.0671	-0.0767
288	QG-52	-0.0500	-0.0487	-0.0499	-0.0487	-0.0497	-0.0487	-0.0507
289	QG-53	-0.1100	-0.1082	-0.1143	-0.1241	-0.1092	-0.1114	-0.1095
290	QG-54	-0.2810	-0.2778	-0.2810	-0.2778	-0.2788	-0.2810	-0.2778
291	QG-55	-0.1734	-0.1737	-0.1738	-0.1737	-0.1727	-0.1737	-0.1717
292	QG-56	-0.2029	NA	-0.2179	-0.1777	-0.2075	-0.2149	-0.2035
293	QG-57	-0.0300	NA	-0.0341	-0.0876	-0.0230	-0.0333	-0.0235
294	QG-58	-0.0300	NA	-0.0277	-0.0268	-0.0298	-0.0267	-0.0290
295	QG-59	-0.3617	NA	-0.3507	-0.3515	-0.3680	-0.3580	-0.3735
296	QG-60	-0.0300	NA	-0.0307	-0.0183	-0.0238	-0.0267	-0.0313
297	QG-61	-0.4039	-0.3930	-0.3958	-0.3930	-0.3940	-0.3930	-0.3930
298	QG-62	-0.1274	NA	-0.1461	-0.1637	-0.1478	-0.1518	-0.1410
299	QG-63	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0003
300	QG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
301	QG-65	0.8151	NA	0.7946	0.7035	0.8198	0.7976	0.8209
302	QG-66	-0.1996	-0.2026	-0.1967	-0.2026	-0.2016	-0.1943	-0.2026
303	QG-67	-0.0700	NA	-0.0623	-0.0645	-0.0662	-0.0660	-0.0631
304	QG-68	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
305	QG-69	-0.8242	NA	-0.7881	-0.8003	-0.8016	-0.7966	-0.7932
306	QG-70	-0.1033	-0.1048	-0.1004	-0.1048	-0.1038	-0.1012	-0.1048
307	QG-71	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
308	QG-72	-0.1113	NA	-0.1045	-0.1091	-0.1092	-0.1058	-0.1103
309	QG-73	0.0965	NA	0.1056	0.1300	0.0969	0.1047	0.0959
310	QG-74	-0.3263	NA	-0.3310	-0.3368	-0.3289	-0.3307	-0.3267
311	QG-75	-0.1100	NA	-0.1341	-0.1351	-0.1193	-0.1194	-0.1198
312	QG-76	-0.3073	NA	-0.3159	-0.3264	-0.3166	-0.3172	-0.3179
313	QG-77	-0.1583	-0.1630	-0.1634	-0.1630	-0.1640	-0.1630	-0.1630
314	QG-78	-0.2600	NA	-0.2211	-0.2085	-0.2293	-0.2266	-0.2345
315	QG-79	-0.3200	-0.3166	-0.3145	-0.3166	-0.3153	-0.3153	-0.3166
316	QG-80	0.7947	NA	0.7901	0.8470	0.7837	0.7859	0.8062
317	QG-81	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0172
318	QG-82	-0.2700	NA	-0.2704	-0.2766	-0.2717	-0.2634	-0.2706
319	QG-83	-0.1000	-0.0972	-0.0934	-0.0972	-0.0962	-0.1010	-0.0972
320	QG-84	-0.0700	NA	-0.0789	-0.0726	-0.0744	-0.0727	-0.0719
321	QG-85	-0.2061	-0.2070	-0.2107	-0.2113	-0.2080	-0.2107	-0.2090
322	QG-86	-0.1000	-0.0989	-0.1017	-0.1023	-0.1023	-0.1023	-0.1023

323	QG-87	0.1102	NA	0.1118	0.1112	0.1122	0.1112	0.1112
324	QG-88	-0.1000	NA	-0.1035	-0.0965	-0.0967	-0.0959	-0.0968
325	QG-89	-0.0590	-0.0584	-0.0626	-0.0584	-0.0594	-0.0626	-0.0584
326	QG-90	0.1731	0.1751	0.1727	0.1751	0.1761	0.1751	0.1751
327	QG-91	-0.1309	NA	-0.1220	-0.1264	-0.1340	-0.1315	-0.1344
328	QG-92	-0.2396	-0.2305	-0.2357	-0.2305	-0.2315	-0.2357	-0.2325
329	QG-93	-0.0700	NA	-0.1014	-0.0842	-0.0822	-0.0775	-0.0772
330	QG-94	-0.1600	NA	-0.1166	-0.1599	-0.1316	-0.1461	-0.1392
331	QG-95	-0.3100	NA	-0.3155	-0.3150	-0.3151	-0.3150	-0.3148
332	QG-96	-0.1500	-0.1482	-0.1493	-0.1482	-0.1482	-0.1482	-0.1482
333	QG-97	-0.0900	-0.0931	-0.0902	-0.0931	-0.0921	-0.0931	-0.0931
334	QG-98	-0.0800	-0.0825	-0.0816	-0.0825	-0.0815	-0.0816	-0.0825
335	QG-99	-0.1754	-0.1684	-0.1712	-0.1684	-0.1694	-0.1684	-0.1684
336	QG-100	0.7755	NA	0.7780	0.8698	0.7623	0.7614	0.7611
337	QG-101	-0.1500	NA	-0.1641	-0.2304	-0.1556	-0.1472	-0.1594
338	QG-102	-0.0300	-0.0298	-0.0331	-0.0298	-0.0308	-0.0331	-0.0298
339	QG-103	0.5942	NA	0.5872	0.6036	0.5828	0.5899	0.5826
340	QG-104	-0.2261	-0.2255	-0.2230	-0.2255	-0.2245	-0.2255	-0.2268
341	QG-105	-0.4433	-0.4472	-0.4437	-0.4472	-0.4462	-0.4450	-0.4472
342	QG-106	-0.1600	NA	-0.1547	-0.1580	-0.1580	-0.1550	-0.1534
343	QG-107	-0.0544	NA	-0.0536	-0.0656	-0.0522	-0.0538	-0.0532
344	QG-108	-0.0100	NA	-0.0166	-0.0156	-0.0155	-0.0176	-0.0181
345	QG-109	-0.0300	NA	-0.0275	-0.0172	-0.0317	-0.0264	-0.0317
346	QG-110	-0.2972	-0.2865	-0.2853	-0.2865	-0.2864	-0.2865	-0.2865
347	QG-111	-0.0184	-0.0186	-0.0208	-0.0480	-0.0196	-0.0186	-0.0186
348	QG-112	0.2851	0.2812	0.2731	0.2812	0.2802	0.2736	0.2812
349	QG-113	0.0675	NA	0.0533	0.0515	0.0674	0.0465	0.0673
350	QG-114	-0.0300	NA	-0.0288	-0.0300	-0.0300	-0.0300	-0.0300
351	QG-115	-0.0700	NA	-0.0696	-0.0710	-0.0709	-0.0709	-0.0709
352	QG-116	0.5132	0.4975	0.4895	0.4934	0.4944	0.4895	0.4934
353	QG-117	-0.0800	-0.0800	-0.0827	-0.0808	-0.0810	-0.0809	-0.0812
354	QG-118	-0.1500	-0.1544	-0.1543	-0.1537	-0.1536	-0.1535	-0.1544
355	PF 1-2	-0.1235	-0.1248	-0.1219	-0.1248	-0.1238	-0.1248	-0.1248
356	PF 1-3	-0.3865	NA	-0.3919	-0.3945	-0.3931	-0.3942	-0.3948
357	PF 4-5	-1.0323	NA	-1.0380	-1.0377	-1.0357	-1.0377	-1.0347
358	PF 3-5	-0.6811	-0.6751	-0.6805	-0.6829	-0.6811	-0.6825	-0.6819
359	PF 5-6	0.8847	0.8771	0.8819	0.8858	0.8820	0.8827	0.8826
360	PF 6-7	0.3554	0.3614	0.3633	0.3614	0.3624	0.3614	0.3614
361	PF 8-9	-4.4064	NA	-4.3902	-4.3908	-4.3891	-4.3909	-4.3909
362	PF 8-5	3.3847	NA	3.3724	3.3606	3.3831	3.3740	3.3853
363	PF 9-10	-4.4525	-4.4367	-4.4361	-4.4367	-4.4357	-4.4367	-4.4367
364	PF 4-11	0.6423	0.6419	0.6421	0.6419	0.6409	0.6419	0.6404

365	PF 5-11	0.7722	0.7812	0.7728	0.7725	0.7713	0.7725	0.7706
366	PF 11-12	0.3429	NA	0.3425	0.3459	0.3448	0.3425	0.3458
367	PF 2-12	-0.3245	-0.3309	-0.3303	-0.3309	-0.3299	-0.3309	-0.3309
368	PF 3-12	-0.0979	NA	-0.0977	-0.0990	-0.0984	-0.0991	-0.0989
369	PF 7-12	0.1648	0.1617	0.1640	0.1617	0.1627	0.1640	0.1617
370	PF 11-13	0.3509	NA	0.3481	0.3481	0.3492	0.3474	0.3490
371	PF 12-14	0.1831	0.1837	0.1847	0.1837	0.1847	0.1837	0.1837
372	PF 13-15	0.0077	NA	0.0063	0.0069	0.0079	0.0062	0.0077
373	PF 14-15	0.0424	0.0422	0.0390	0.0399	0.0412	0.0390	0.0411
374	PF 12-16	0.0751	NA	0.0708	0.0716	0.0734	0.0705	0.0723
375	PF 15-17	-1.0386	NA	-1.0459	-1.0460	-1.0388	-1.0430	-1.0391
376	PF 16-17	-0.1751	NA	-0.1780	-0.1766	-0.1756	-0.1777	-0.1759
377	PF 17-18	0.8027	0.8065	0.8083	0.8065	0.8055	0.8065	0.8065
378	PF 18-19	0.1939	NA	0.1971	0.1961	0.1923	0.1963	0.1919
379	PF 19-20	-0.1062	NA	-0.1055	-0.1123	-0.1103	-0.1043	-0.1103
380	PF 15-19	0.1153	NA	0.1169	0.1133	0.1163	0.1170	0.1164
381	PF 20-21	-0.2867	NA	-0.2866	-0.2903	-0.2893	-0.2854	-0.2884
382	PF 21-22	-0.4284	-0.4366	-0.4282	-0.4337	-0.4356	-0.4282	-0.4351
383	PF 22-23	-0.5326	NA	-0.5227	-0.5241	-0.5251	-0.5241	-0.5241
384	PF 23-24	0.0828	0.0828	0.0801	0.0828	0.0838	0.0801	0.0828
385	PF 23-25	-1.6256	NA	-1.6485	-1.6481	-1.6516	-1.6525	-1.6520
386	PF 26-25	0.9029	NA	0.8950	0.9028	0.9018	0.8950	0.9013
387	PF 25-27	1.4352	NA	1.4434	1.4550	1.4509	1.4462	1.4495
388	PF 27-28	0.3288	NA	0.3295	0.3318	0.3328	0.3322	0.3318
389	PF 28-29	0.1566	0.1557	0.1529	0.1557	0.1553	0.1529	0.1557
390	PF 30-17	2.3119	2.2708	2.2854	2.3033	2.3083	2.2873	2.3038
391	PF 8-30	0.7416	NA	0.7354	0.7478	0.7246	0.7345	0.7232
392	PF 26-30	2.2371	NA	2.2233	2.2531	2.2599	2.2284	2.2593
393	PF 17-31	0.1477	0.1473	0.1561	0.1515	0.1508	0.1573	0.1509
394	PF 29-31	-0.0842	NA	-0.0833	-0.0828	-0.0836	-0.0846	-0.0832
395	PF 23-32	0.9298	0.9357	0.9279	0.9357	0.9338	0.9279	0.9316
396	PF 31-32	-0.2986	NA	-0.2937	-0.2996	-0.3003	-0.2958	-0.2993
397	PF 27-32	0.1253	NA	0.1290	0.1285	0.1265	0.1285	0.1270
398	PF 15-33	0.0731	NA	0.0754	0.0824	0.0754	0.0756	0.0762
399	PF 19-34	-0.0359	NA	-0.0348	-0.0305	-0.0344	-0.0346	-0.0336
400	PF 35-36	0.0084	NA	0.0084	0.0070	0.0083	0.0071	0.0070
401	PF 35-37	-0.3384	NA	-0.3387	-0.3366	-0.3388	-0.3365	-0.3366
402	PF 33-37	-0.1572	NA	-0.1578	-0.1566	-0.1573	-0.1566	-0.1555
403	PF 34-36	0.3025	0.2981	0.2975	0.2981	0.2979	0.2981	0.2981
404	PF 34-37	-0.9431	NA	-0.9588	-0.9451	-0.9588	-0.9446	-0.9443
405	PF 38-37	2.4337	NA	2.4460	2.4896	2.4495	2.4447	2.4523
406	PF 37-39	0.5491	NA	0.5432	0.5349	0.5369	0.5435	0.5411

407	PF 37-40	0.4402	0.4325	0.4372	0.4325	0.4335	0.4372	0.4357
408	PF 30-38	0.6235	NA	0.6305	0.6539	0.6313	0.6328	0.6345
409	PF 39-40	0.2692	0.2706	0.2706	0.2706	0.2716	0.2706	0.2706
410	PF 40-41	0.1545	0.1569	0.1577	0.1569	0.1579	0.1569	0.1569
411	PF 40-42	-0.1184	NA	-0.1146	-0.1143	-0.1140	-0.1141	-0.1147
412	PF 41-42	-0.2159	NA	-0.2119	-0.2112	-0.2112	-0.2110	-0.2117
413	PF 43-44	-0.1659	-0.1655	-0.1677	-0.1655	-0.1665	-0.1666	-0.1666
414	PF 34-43	0.0141	0.0140	0.0134	0.0140	0.0130	0.0140	0.0140
415	PF 44-45	-0.3277	NA	-0.3290	-0.3255	-0.3274	-0.3266	-0.3266
416	PF 45-46	-0.3633	NA	-0.3594	-0.3644	-0.3630	-0.3602	-0.3639
417	PF 46-47	-0.3111	NA	-0.3092	-0.3108	-0.3104	-0.3092	-0.3111
418	PF 46-48	-0.1476	-0.1475	-0.1462	-0.1475	-0.1474	-0.1470	-0.1481
419	PF 47-49	-0.0954	NA	-0.0960	-0.0972	-0.0976	-0.0978	-0.0975
420	PF 42-49	-0.6487	NA	-0.6485	-0.6487	-0.6481	-0.6485	-0.6492
421	PF 42-49	-0.6487	NA	-0.6485	-0.6487	-0.6481	-0.6485	-0.6492
422	PF 45-49	-0.4970	-0.4872	-0.4931	-0.4967	-0.4968	-0.4942	-0.4978
423	PF 48-49	-0.3490	NA	-0.3500	-0.3492	-0.3502	-0.3492	-0.3492
424	PF 49-50	0.5366	NA	0.5312	0.5281	0.5291	0.5281	0.5302
425	PF 49-51	0.6663	NA	0.6738	0.6746	0.6728	0.6733	0.6705
426	PF 51-52	0.2856	NA	0.2870	0.2885	0.2874	0.2885	0.2885
427	PF 52-53	0.1037	0.1033	0.1032	0.1040	0.1039	0.1035	0.1044
428	PF 53-54	-0.1268	NA	-0.1300	-0.1287	-0.1298	-0.1292	-0.1298
429	PF 49-54	0.3777	NA	0.3796	0.3812	0.3800	0.3802	0.3795
430	PF 49-54	0.3774	NA	0.3794	0.3811	0.3798	0.3800	0.3792
431	PF 54-55	0.0707	0.0714	0.0723	0.0732	0.0723	0.0727	0.0721
432	PF 54-56	0.1853	NA	0.1861	0.1864	0.1874	0.1864	0.1864
433	PF 55-56	-0.2142	NA	-0.2210	-0.2247	-0.2203	-0.2227	-0.2199
434	PF 56-57	-0.2299	-0.2260	-0.2285	-0.2260	-0.2270	-0.2285	-0.2260
435	PF 50-57	0.3588	0.3629	0.3672	0.3731	0.3703	0.3701	0.3691
436	PF 56-58	-0.0667	NA	-0.0640	-0.0659	-0.0649	-0.0654	-0.0654
437	PF 51-58	0.1879	0.1886	0.1872	0.1886	0.1876	0.1886	0.1886
438	PF 54-59	-0.3038	NA	-0.3029	-0.3007	-0.3050	-0.3032	-0.3052
439	PF 56-59	-0.2796	NA	-0.2790	-0.2770	-0.2807	-0.2791	-0.2807
440	PF 56-59	-0.2931	NA	-0.2925	-0.2903	-0.2942	-0.2926	-0.2943
441	PF 55-59	-0.3452	NA	-0.3447	-0.3426	-0.3469	-0.3451	-0.3470
442	PF 59-60	-0.4332	-0.4372	-0.4344	-0.4372	-0.4362	-0.4345	-0.4356
443	PF 59-61	-0.5172	NA	-0.5174	-0.5212	-0.5182	-0.5175	-0.5177
444	PF 60-61	-1.1207	NA	-1.1089	-1.1220	-1.0995	-1.1089	-1.1000
445	PF 60-62	-0.0987	-0.1004	-0.0907	-0.0992	-0.0832	-0.0907	-0.0852
446	PF 61-62	0.2549	NA	0.2626	0.2544	0.2703	0.2625	0.2676
447	PF 63-59	1.5177	NA	1.5247	1.5352	1.5161	1.5247	1.5122
448	PF 63-64	-1.5177	NA	-1.5247	-1.5352	-1.5343	-1.5247	-1.5338

449	PF 64-61	0.3054	NA	0.3187	0.3194	0.3105	0.3187	0.3083
450	PF 38-65	-1.8128	NA	-1.8180	-1.8383	-1.8198	-1.8146	-1.8202
451	PF 64-65	-1.8279	-1.8604	-1.8483	-1.8595	-1.8506	-1.8483	-1.8472
452	PF 49-66	-1.3222	NA	-1.3268	-1.3285	-1.3280	-1.3266	-1.3282
453	PF 49-66	-1.3222	NA	-1.3268	-1.3285	-1.3280	-1.3266	-1.3282
454	PF 62-66	-0.3716	NA	-0.3781	-0.3776	-0.3778	-0.3782	-0.3768
455	PF 62-67	-0.2430	-0.2387	-0.2472	-0.2387	-0.2397	-0.2472	-0.2387
456	PF 65-66	0.0854	NA	0.0815	0.0871	0.0861	0.0810	0.0851
457	PF 66-67	0.5316	NA	0.5416	0.5507	0.5498	0.5416	0.5489
458	PF 65-68	0.1418	0.1442	0.1500	0.1442	0.1452	0.1500	0.1442
459	PF 47-69	-0.5594	-0.5525	-0.5603	-0.5628	-0.5609	-0.5605	-0.5612
460	PF 49-69	-0.4654	NA	-0.4659	-0.4677	-0.4662	-0.4658	-0.4665
461	PF 68-69	-1.2580	NA	-1.2466	-1.2432	-1.2422	-1.2466	-1.2432
462	PF 69-70	1.0838	NA	1.0863	1.0841	1.0812	1.0841	1.0809
463	PF 24-70	-0.0622	NA	-0.0667	-0.0647	-0.0627	-0.0660	-0.0627
464	PF 70-71	0.1665	NA	0.1728	0.1704	0.1688	0.1716	0.1671
465	PF 24-72	0.0147	NA	0.0128	0.0149	0.0149	0.0135	0.0144
466	PF 71-72	0.1060	0.1072	0.1119	0.1107	0.1072	0.1119	0.1072
467	PF 71-73	0.0601	0.0592	0.0605	0.0592	0.0602	0.0592	0.0592
468	PF 70-74	0.1621	NA	0.1617	0.1634	0.1631	0.1621	0.1637
469	PF 70-75	-0.0013	NA	-0.0001	0.0015	0.0018	0.0005	0.0021
470	PF 69-75	1.1001	1.1016	1.1030	1.1016	1.1012	1.1017	1.1016
471	PF 74-75	-0.5199	-0.5134	-0.5138	-0.5134	-0.5124	-0.5134	-0.5134
472	PF 76-77	-0.6115	-0.6192	-0.6141	-0.6172	-0.6132	-0.6139	-0.6129
473	PF 69-77	0.6221	NA	0.6192	0.6168	0.6194	0.6188	0.6194
474	PF 75-77	-0.3461	NA	-0.3493	-0.3503	-0.3481	-0.3487	-0.3483
475	PF 77-78	0.4539	NA	0.4680	0.4603	0.4679	0.4662	0.4685
476	PF 78-79	-0.2568	-0.2595	-0.2596	-0.2595	-0.2585	-0.2595	-0.2595
477	PF 77-80	-0.9657	NA	-0.9740	-0.9751	-0.9724	-0.9731	-0.9731
478	PF 77-80	-0.4437	NA	-0.4477	-0.4480	-0.4470	-0.4474	-0.4472
479	PF 79-80	-0.6474	NA	-0.6561	-0.6552	-0.6552	-0.6552	-0.6552
480	PF 68-81	-0.4415	NA	-0.4492	-0.4430	-0.4449	-0.4492	-0.4446
481	PF 81-80	-0.4420	-0.4435	-0.4497	-0.4435	-0.4445	-0.4497	-0.4450
482	PF 77-82	-0.0303	-0.0304	-0.0322	-0.0304	-0.0314	-0.0316	-0.0304
483	PF 82-83	-0.4722	NA	-0.4750	-0.4792	-0.4783	-0.4750	-0.4793
484	PF 83-84	-0.2479	NA	-0.2479	-0.2554	-0.2503	-0.2484	-0.2528
485	PF 83-85	-0.4277	NA	-0.4286	-0.4290	-0.4321	-0.4282	-0.4301
486	PF 84-85	-0.3635	-0.3682	-0.3628	-0.3503	-0.3672	-0.3628	-0.3580
487	PF 85-86	0.1717	NA	0.1708	0.1721	0.1728	0.1721	0.1734
488	PF 86-87	-0.0395	-0.0392	-0.0397	-0.0392	-0.0395	-0.0392	-0.0392
489	PF 85-88	-0.5039	-0.4945	-0.4990	-0.4946	-0.5070	-0.4998	-0.5000
490	PF 85-89	-0.7124	NA	-0.7114	-0.7084	-0.7161	-0.7114	-0.7116

491	PF 88-89	-0.9893	NA	-0.9939	-0.9933	-0.9943	-0.9933	-0.9933
492	PF 89-90	0.5822	NA	0.5850	0.5833	0.5855	0.5850	0.5847
493	PF 89-90	1.1083	NA	1.1138	1.1105	1.1146	1.1137	1.1130
494	PF 90-91	0.0141	NA	0.0092	0.0060	0.0110	0.0106	0.0082
495	PF 89-92	2.0154	NA	2.0138	2.0068	2.0224	2.0116	2.0137
496	PF 89-92	0.6359	NA	0.6354	0.6333	0.6382	0.6347	0.6354
497	PF 91-92	-0.0860	-0.0850	-0.0875	-0.0850	-0.0860	-0.0892	-0.0862
498	PF 92-93	0.5762	0.5728	0.5741	0.5728	0.5738	0.5728	0.5728
499	PF 92-94	0.5217	NA	0.5233	0.5229	0.5293	0.5232	0.5250
500	PF 93-94	0.4472	NA	0.4516	0.4533	0.4660	0.4543	0.4580
501	PF 94-95	0.4086	0.4122	0.4114	0.4122	0.4112	0.4122	0.4107
502	PF 80-96	0.1897	NA	0.1902	0.1912	0.1905	0.1906	0.1911
503	PF 82-96	-0.0994	-0.0979	-0.1015	-0.1015	-0.1013	-0.1015	-0.1016
504	PF 94-96	0.1979	NA	0.1978	0.1965	0.1972	0.1970	0.1971
505	PF 80-97	0.2642	NA	0.2645	0.2649	0.2647	0.2643	0.2655
506	PF 80-98	0.2895	NA	0.2900	0.2930	0.2914	0.2902	0.2912
507	PF 80-99	0.1956	NA	0.1966	0.1988	0.1975	0.1978	0.1980
508	PF 92-100	0.3150	0.3211	0.3162	0.3166	0.3192	0.3158	0.3164
509	PF 94-100	0.0428	NA	0.0438	0.0435	0.0440	0.0431	0.0430
510	PF 95-96	-0.0138	-0.0136	-0.0161	-0.0187	-0.0169	-0.0180	-0.0167
511	PF 96-97	-0.1110	NA	-0.1118	-0.1132	-0.1121	-0.1126	-0.1124
512	PF 98-100	-0.0526	-0.0517	-0.0519	-0.0517	-0.0523	-0.0517	-0.0519
513	PF 99-100	-0.2265	-0.2226	-0.2268	-0.2277	-0.2279	-0.2287	-0.2285
514	PF 100-101	-0.1674	-0.1698	-0.1694	-0.1698	-0.1708	-0.1698	-0.1698
515	PF 92-102	0.4465	NA	0.4467	0.4433	0.4511	0.4457	0.4475
516	PF 101-102	-0.3898	-0.3877	-0.3895	-0.3877	-0.3942	-0.3898	-0.3902
517	PF 100-103	1.2175	NA	1.2122	1.2135	1.2125	1.2136	1.2136
518	PF 100-104	0.5618	NA	0.5571	0.5586	0.5581	0.5583	0.5584
519	PF 103-104	0.3245	NA	0.3199	0.3220	0.3212	0.3211	0.3213
520	PF 103-105	0.4335	NA	0.4289	0.4315	0.4305	0.4307	0.4307
521	PF 100-106	0.6036	0.5930	0.5986	0.6008	0.6001	0.6007	0.6008
522	PF 104-105	0.4858	NA	0.4857	0.4871	0.4869	0.4879	0.4877
523	PF 105-105	0.0886	NA	0.0855	0.0877	0.0867	0.0877	0.0877

524	PF 105-107	0.2675	NA	0.2675	0.2686	0.2673	0.2686	0.2686
525	PF 105-108	0.2397	0.2396	0.2397	0.2396	0.2406	0.2396	0.2396
526	PF 106-107	0.2398	NA	0.2408	0.2413	0.2403	0.2413	0.2413
527	PF 108-109	0.2177	0.2154	0.2153	0.2154	0.2160	0.2154	0.2154
528	PF 103-110	0.6060	NA	0.6026	0.6037	0.6048	0.6043	0.6042
529	PF 109-110	0.1371	0.1389	0.1405	0.1411	0.1399	0.1404	0.1389
530	PF 110-111	-0.3570	NA	-0.3543	-0.3536	-0.3538	-0.3537	-0.3537
531	PF 110-112	0.6946	NA	0.6861	0.6862	0.6872	0.6861	0.6860
532	PF 17-113	0.0206	0.0206	0.0221	0.0206	0.0216	0.0206	0.0206
533	PF 32-113	0.0412	NA	0.0319	0.0380	0.0396	0.0319	0.0390
534	PF 32-114	0.0937	NA	0.0932	0.0936	0.0946	0.0936	0.0936
535	PF 27-115	0.2072	0.2104	0.2107	0.2104	0.2094	0.2104	0.2089
536	PF 114-115	0.0136	0.0138	0.0137	0.0138	0.0148	0.0138	0.0138
537	PF 68-116	1.8413	NA	1.8457	1.8304	1.8333	1.8457	1.8322
538	PF 12-117	0.2015	0.2001	0.2011	0.2012	0.2011	0.2011	0.2001
539	PF 75-118	0.4021	0.3946	0.3992	0.4035	0.4014	0.4004	0.4004
540	PF 76-118	-0.0685	-0.0676	-0.0665	-0.0676	-0.0666	-0.0676	-0.0661
541	PT 1-2	0.1245	NA	0.1228	0.1257	0.1247	0.1257	0.1257
542	PT 1-3	0.3890	NA	0.3945	0.3971	0.3956	0.3968	0.3974
543	PT 4-5	1.0343	NA	1.0401	1.0398	1.0377	1.0397	1.0367
544	PT 3-5	0.6935	NA	0.6929	0.6955	0.6935	0.6950	0.6942
545	PT 5-6	-0.8754	NA	-0.8727	-0.8765	-0.8728	-0.8734	-0.8734
546	PT 6-7	-0.3548	NA	-0.3627	-0.3608	-0.3618	-0.3608	-0.3608
547	PT 8-9	4.4525	NA	4.4361	4.4367	4.4347	4.4367	4.4365
548	PT 8-5	-3.3847	NA	-3.3724	-3.3606	-3.3831	-3.3740	-3.3853
549	PT 9-10	4.5000	NA	4.4831	4.4834	4.4826	4.4838	4.4837
550	PT 4-11	-0.6336	NA	-0.6335	-0.6332	-0.6323	-0.6332	-0.6318
551	PT 5-11	-0.7602	NA	-0.7607	-0.7604	-0.7593	-0.7604	-0.7586
552	PT 11-12	-0.3415	-0.3444	-0.3410	-0.3444	-0.3434	-0.3410	-0.3444
553	PT 2-12	0.3273	NA	0.3333	0.3340	0.3329	0.3340	0.3339
554	PT 3-12	0.0989	NA	0.0987	0.1001	0.0995	0.1002	0.1000
555	PT 7-12	-0.1645	NA	-0.1637	-0.1614	-0.1624	-0.1637	-0.1614
556	PT 11-13	-0.3477	-0.3450	-0.3449	-0.3450	-0.3460	-0.3443	-0.3458

557	PT 12-14	-0.1824	NA	-0.1839	-0.1829	-0.1839	-0.1829	-0.1829
558	PT 13-15	-0.0077	-0.0078	-0.0063	-0.0069	-0.0079	-0.0062	-0.0077
559	PT 14-15	-0.0421	NA	-0.0387	-0.0397	-0.0409	-0.0387	-0.0408
560	PT 12-16	-0.0749	NA	-0.0706	-0.0714	-0.0732	-0.0703	-0.0721
561	PT 15-17	1.0544	1.0682	1.0619	1.0620	1.0545	1.0589	1.0549
562	PT 16-17	0.1766	NA	0.1795	0.1781	0.1771	0.1792	0.1773
563	PT 17-18	-0.7939	NA	-0.7994	-0.7977	-0.7967	-0.7977	-0.7977
564	PT 18-19	-0.1931	-0.1964	-0.1963	-0.1953	-0.1915	-0.1955	-0.1911
565	PT 19-20	0.1067	NA	0.1059	0.1127	0.1107	0.1047	0.1108
566	PT 15-19	-0.1147	NA	-0.1164	-0.1128	-0.1157	-0.1165	-0.1159
567	PT 20-21	0.2884	0.2920	0.2882	0.2920	0.2910	0.2870	0.2901
568	PT 21-22	0.4326	0.4249	0.4323	0.4379	0.4399	0.4323	0.4394
569	PT 22-23	0.5430	0.5341	0.5327	0.5341	0.5351	0.5341	0.5341
570	PT 23-24	-0.0825	NA	-0.0798	-0.0825	-0.0835	-0.0798	-0.0825
571	PT 23-25	1.6676	1.6958	1.6915	1.6913	1.6948	1.6958	1.6953
572	PT 26-25	-0.9029	-0.9028	-0.8950	-0.9028	-0.9018	-0.8950	-0.9013
573	PT 25-27	-1.3713	NA	-1.3790	-1.3899	-1.3858	-1.3815	-1.3844
574	PT 27-28	-0.3266	-0.3295	-0.3273	-0.3295	-0.3305	-0.3299	-0.3295
575	PT 28-29	-0.1558	NA	-0.1522	-0.1550	-0.1546	-0.1522	-0.1550
576	PT 30-17	-2.3119	NA	-2.2854	-2.3033	-2.3083	-2.2873	-2.3038
577	PT 8-30	-0.7381	-0.7443	-0.7319	-0.7443	-0.7211	-0.7310	-0.7197
578	PT 26-30	-2.1973	NA	-2.1841	-2.2129	-2.2195	-2.1890	-2.2188
579	PT 17-31	-0.1457	NA	-0.1542	-0.1497	-0.1489	-0.1554	-0.1490
580	PT 29-31	0.0843	0.0848	0.0835	0.0829	0.0838	0.0848	0.0834
581	PT 23-32	-0.9020	NA	-0.9003	-0.9078	-0.9058	-0.9002	-0.9037
582	PT 31-32	0.3020	NA	0.2969	0.3029	0.3037	0.2991	0.3028
583	PT 27-32	-0.1249	NA	-0.1286	-0.1281	-0.1261	-0.1281	-0.1266
584	PT 15-33	-0.0728	NA	-0.0751	-0.0821	-0.0751	-0.0753	-0.0759
585	PT 19-34	0.0365	0.0360	0.0355	0.0313	0.0350	0.0353	0.0342
586	PT 35-36	-0.0084	NA	-0.0084	-0.0070	-0.0083	-0.0070	-0.0070
587	PT 35-37	0.3399	0.3413	0.3402	0.3380	0.3403	0.3380	0.3380
588	PT 33-37	0.1586	0.1581	0.1593	0.1581	0.1588	0.1581	0.1570
589	PT 34-36	-0.3016	NA	-0.2967	-0.2973	-0.2971	-0.2973	-0.2973
590	PT 34-37	0.9459	NA	0.9616	0.9479	0.9617	0.9474	0.9471
591	PT 38-37	-2.4337	NA	-2.4460	-2.4896	-2.4495	-2.4447	-2.4523
592	PT 37-39	-0.5392	NA	-0.5335	-0.5255	-0.5275	-0.5338	-0.5315
593	PT 37-40	-0.4285	NA	-0.4257	-0.4213	-0.4222	-0.4257	-0.4243
594	PT 30-38	-0.6209	-0.6122	-0.6279	-0.6512	-0.6287	-0.6301	-0.6319
595	PT 39-40	-0.2676	NA	-0.2690	-0.2690	-0.2700	-0.2690	-0.2690
596	PT 40-41	-0.1541	NA	-0.1573	-0.1565	-0.1575	-0.1565	-0.1565
597	PT 40-42	0.1193	0.1197	0.1155	0.1151	0.1148	0.1150	0.1155
598	PT 41-42	0.2181	0.2177	0.2141	0.2132	0.2133	0.2131	0.2139

599	PT 43-44	0.1677	NA	0.1695	0.1673	0.1683	0.1684	0.1684
600	PT 34-43	-0.0141	NA	-0.0133	-0.0132	-0.0129	-0.0139	-0.0139
601	PT 44-45	0.3303	NA	0.3316	0.3281	0.3300	0.3291	0.3291
602	PT 45-46	0.3687	NA	0.3647	0.3699	0.3684	0.3655	0.3693
603	PT 46-47	0.3148	0.3201	0.3128	0.3144	0.3140	0.3128	0.3147
604	PT 46-48	0.1490	NA	0.1475	0.1488	0.1488	0.1484	0.1495
605	PT 47-49	0.0957	NA	0.0963	0.0975	0.0980	0.0982	0.0979
606	PT 42-49	0.6804	0.6887	0.6802	0.6804	0.6796	0.6802	0.6808
607	PT 42-49	0.6804	0.6755	0.6802	0.6804	0.6796	0.6802	0.6808
608	PT 45-49	0.5144	NA	0.5102	0.5140	0.5141	0.5114	0.5151
609	PT 48-49	0.3511	0.3514	0.3522	0.3514	0.3524	0.3514	0.3514
610	PT 49-50	-0.5288	-0.5205	-0.5235	-0.5205	-0.5215	-0.5205	-0.5225
611	PT 49-51	-0.6435	-0.6555	-0.6507	-0.6511	-0.6497	-0.6501	-0.6475
612	PT 51-52	-0.2837	-0.2866	-0.2851	-0.2866	-0.2855	-0.2866	-0.2866
613	PT 52-53	-0.1032	NA	-0.1027	-0.1035	-0.1034	-0.1029	-0.1038
614	PT 53-54	0.1274	NA	0.1305	0.1292	0.1303	0.1298	0.1304
615	PT 49-54	-0.3658	-0.3600	-0.3676	-0.3690	-0.3680	-0.3682	-0.3675
616	PT 49-54	-0.3638	NA	-0.3656	-0.3671	-0.3660	-0.3662	-0.3655
617	PT 54-55	-0.0706	NA	-0.0722	-0.0731	-0.0722	-0.0726	-0.0720
618	PT 54-56	-0.1852	-0.1863	-0.1859	-0.1863	-0.1873	-0.1863	-0.1863
619	PT 55-56	0.2145	0.2185	0.2213	0.2250	0.2205	0.2230	0.2201
620	PT 56-57	0.2321	NA	0.2307	0.2280	0.2292	0.2307	0.2281
621	PT 50-57	-0.3521	NA	-0.3602	-0.3656	-0.3633	-0.3631	-0.3621
622	PT 56-58	0.0669	0.0661	0.0642	0.0661	0.0651	0.0656	0.0656
623	PT 51-58	-0.1869	NA	-0.1862	-0.1876	-0.1866	-0.1876	-0.1876
624	PT 54-59	0.3090	0.3031	0.3081	0.3058	0.3102	0.3084	0.3104
625	PT 56-59	0.2867	NA	0.2861	0.2840	0.2878	0.2862	0.2879
626	PT 56-59	0.3007	0.3039	0.3001	0.2978	0.3019	0.3002	0.3019
627	PT 55-59	0.3516	NA	0.3511	0.3490	0.3533	0.3515	0.3535
628	PT 59-60	0.4394	NA	0.4407	0.4436	0.4425	0.4408	0.4419
629	PT 59-61	0.5264	0.5182	0.5266	0.5306	0.5275	0.5267	0.5269
630	PT 60-61	1.1241	1.1018	1.1122	1.1254	1.1028	1.1122	1.1033
631	PT 60-62	0.0989	NA	0.0909	0.0993	0.0834	0.0909	0.0853
632	PT 61-62	-0.2542	NA	-0.2619	-0.2538	-0.2696	-0.2618	-0.2669
633	PT 63-59	-1.5177	-1.5040	-1.5247	-1.5352	-1.5161	-1.5247	-1.5122
634	PT 63-64	1.5225	1.5402	1.5296	1.5402	1.5392	1.5296	1.5387
635	PT 64-61	-0.3054	NA	-0.3187	-0.3194	-0.3105	-0.3187	-0.3083
636	PT 38-65	1.8449	NA	1.8502	1.8711	1.8520	1.8467	1.8524
637	PT 64-65	1.8378	NA	1.8585	1.8698	1.8608	1.8585	1.8573
638	PT 49-66	1.3522	1.3473	1.3571	1.3589	1.3582	1.3568	1.3585
639	PT 49-66	1.3522	NA	1.3571	1.3589	1.3582	1.3568	1.3585
640	PT 62-66	0.3793	0.3833	0.3861	0.3856	0.3858	0.3862	0.3847

641	PT 62-67	0.2450	NA	0.2492	0.2406	0.2416	0.2492	0.2406
642	PT 65-66	-0.0854	-0.0871	-0.0815	-0.0871	-0.0861	-0.0810	-0.0851
643	PT 66-67	-0.5250	-0.5210	-0.5348	-0.5436	-0.5428	-0.5348	-0.5419
644	PT 65-68	-0.1418	NA	-0.1499	-0.1442	-0.1452	-0.1499	-0.1442
645	PT 47-69	0.5868	NA	0.5877	0.5905	0.5884	0.5880	0.5887
646	PT 49-69	0.4878	0.4913	0.4883	0.4903	0.4886	0.4882	0.4889
647	PT 68-69	1.2580	1.2432	1.2466	1.2432	1.2422	1.2466	1.2432
648	PT 69-70	-1.0494	NA	-1.0519	-1.0498	-1.0471	-1.0499	-1.0468
649	PT 24-70	0.0622	0.0617	0.0668	0.0648	0.0627	0.0660	0.0628
650	PT 70-71	-0.1661	NA	-0.1724	-0.1700	-0.1684	-0.1711	-0.1667
651	PT 24-72	-0.0145	-0.0148	-0.0127	-0.0148	-0.0147	-0.0134	-0.0143
652	PT 71-72	-0.1055	NA	-0.1113	-0.1102	-0.1066	-0.1113	-0.1067
653	PT 71-73	-0.0600	NA	-0.0603	-0.0591	-0.0601	-0.0591	-0.0591
654	PT 70-74	-0.1601	-0.1601	-0.1596	-0.1612	-0.1611	-0.1601	-0.1617
655	PT 70-75	0.0019	NA	0.0008	-0.0008	-0.0011	0.0002	-0.0014
656	PT 69-75	-1.0516	NA	-1.0541	-1.0527	-1.0526	-1.0531	-1.0529
657	PT 74-75	0.5236	NA	0.5174	0.5170	0.5159	0.5169	0.5169
658	PT 76-77	0.6321	NA	0.6350	0.6385	0.6340	0.6348	0.6337
659	PT 69-77	-0.6105	-0.6042	-0.6077	-0.6054	-0.6079	-0.6073	-0.6079
660	PT 75-77	0.3541	0.3483	0.3575	0.3587	0.3563	0.3569	0.3565
661	PT 77-78	-0.4532	NA	-0.4672	-0.4595	-0.4671	-0.4654	-0.4676
662	PT 78-79	0.2574	NA	0.2602	0.2600	0.2590	0.2600	0.2600
663	PT 77-80	0.9834	NA	0.9918	0.9931	0.9902	0.9909	0.9910
664	PT 77-80	0.4505	NA	0.4546	0.4549	0.4538	0.4542	0.4541
665	PT 79-80	0.6550	0.6666	0.6639	0.6630	0.6629	0.6629	0.6629
666	PT 68-81	0.4420	NA	0.4497	0.4435	0.4455	0.4497	0.4452
667	PT 81-80	0.4420	NA	0.4497	0.4435	0.4445	0.4497	0.4450
668	PT 77-82	0.0317	NA	0.0337	0.0318	0.0328	0.0330	0.0318
669	PT 82-83	0.4756	0.4827	0.4784	0.4827	0.4817	0.4784	0.4827
670	PT 83-84	0.2535	NA	0.2537	0.2612	0.2560	0.2540	0.2586
671	PT 83-85	0.4367	NA	0.4377	0.4380	0.4412	0.4372	0.4391
672	PT 84-85	0.3679	NA	0.3672	0.3544	0.3717	0.3672	0.3623
673	PT 85-86	-0.1705	-0.1726	-0.1697	-0.1709	-0.1716	-0.1709	-0.1721
674	PT 86-87	0.0400	0.0398	0.0402	0.0398	0.0401	0.0398	0.0398
675	PT 85-88	0.5093	NA	0.5044	0.4998	0.5124	0.5051	0.5053
676	PT 85-89	0.7249	NA	0.7239	0.7207	0.7287	0.7239	0.7240
677	PT 88-89	1.0033	1.0074	1.0080	1.0074	1.0084	1.0074	1.0074
678	PT 89-90	-0.5648	NA	-0.5675	-0.5659	-0.5680	-0.5675	-0.5672
679	PT 89-90	-1.0793	-1.0881	-1.0846	-1.0815	-1.0855	-1.0846	-1.0840
680	PT 90-91	-0.0140	NA	-0.0091	-0.0059	-0.0109	-0.0105	-0.0081
681	PT 89-92	-1.9756	NA	-1.9740	-1.9674	-1.9825	-1.9720	-1.9741
682	PT 89-92	-0.6202	NA	-0.6196	-0.6177	-0.6223	-0.6190	-0.6197

683	PT 91-92	0.0864	NA	0.0879	0.0854	0.0864	0.0896	0.0866
684	PT 92-93	-0.5672	NA	-0.5652	-0.5639	-0.5649	-0.5639	-0.5639
685	PT 92-94	-0.5075	-0.5024	-0.5089	-0.5086	-0.5148	-0.5090	-0.5106
686	PT 93-94	-0.4418	NA	-0.4459	-0.4477	-0.4601	-0.4488	-0.4524
687	PT 94-95	-0.4062	NA	-0.4090	-0.4098	-0.4088	-0.4098	-0.4083
688	PT 80-96	-0.1866	NA	-0.1872	-0.1881	-0.1875	-0.1875	-0.1880
689	PT 82-96	0.0996	NA	0.1017	0.1017	0.1014	0.1017	0.1018
690	PT 94-96	-0.1966	-0.1949	-0.1965	-0.1953	-0.1959	-0.1957	-0.1958
691	PT 80-97	-0.2618	NA	-0.2621	-0.2625	-0.2623	-0.2619	-0.2631
692	PT 80-98	-0.2874	-0.2837	-0.2879	-0.2909	-0.2893	-0.2882	-0.2891
693	PT 80-99	-0.1935	NA	-0.1945	-0.1967	-0.1954	-0.1956	-0.1958
694	PT 92-100	-0.3071	NA	-0.3082	-0.3086	-0.3112	-0.3079	-0.3086
695	PT 94-100	-0.0387	-0.0390	-0.0397	-0.0390	-0.0400	-0.0390	-0.0390
696	PT 95-96	0.0145	NA	0.0169	0.0196	0.0177	0.0188	0.0175
697	PT 96-97	0.1118	0.1119	0.1126	0.1141	0.1129	0.1135	0.1132
698	PT 98-100	0.0528	NA	0.0521	0.0518	0.0525	0.0519	0.0521
699	PT 99-100	0.2274	NA	0.2278	0.2286	0.2289	0.2296	0.2294
700	PT 100-101	0.1698	NA	0.1720	0.1730	0.1732	0.1721	0.1722
701	PT 92-102	-0.4439	NA	-0.4441	-0.4408	-0.4485	-0.4431	-0.4449
702	PT 101-102	0.3939	NA	0.3936	0.3917	0.3984	0.3940	0.3943
703	PT 100-103	-1.1940	-1.1903	-1.1890	-1.1903	-1.1893	-1.1903	-1.1903
704	PT 100-104	-0.5473	NA	-0.5429	-0.5442	-0.5438	-0.5439	-0.5440
705	PT 103-104	-0.3185	NA	-0.3141	-0.3161	-0.3154	-0.3153	-0.3154
706	PT 103-105	-0.4225	NA	-0.4181	-0.4206	-0.4196	-0.4198	-0.4199
707	PT 100-106	-0.5814	NA	-0.5768	-0.5788	-0.5781	-0.5787	-0.5788
708	PT 104-105	-0.4833	-0.4854	-0.4832	-0.4846	-0.4844	-0.4854	-0.4852
709	PT 105-105	-0.0885	-0.0875	-0.0854	-0.0875	-0.0865	-0.0876	-0.0875
710	PT 105-107	-0.2635	NA	-0.2635	-0.2646	-0.2632	-0.2645	-0.2645
711	PT 105-108	-0.2377	NA	-0.2378	-0.2377	-0.2387	-0.2377	-0.2377
712	PT 106-107	-0.2365	-0.2379	-0.2375	-0.2379	-0.2369	-0.2379	-0.2379

713	PT 108-109	-0.2171	-0.2143	-0.2147	-0.2147	-0.2153	-0.2147	-0.2147
714	PT 103-110	-0.5915	NA	-0.5883	-0.5893	-0.5904	-0.5899	-0.5899
715	PT 109-110	-0.1361	NA	-0.1395	-0.1401	-0.1388	-0.1393	-0.1378
716	PT 110-111	0.3600	NA	0.3573	0.3566	0.3568	0.3566	0.3566
717	PT 110-112	-0.6800	NA	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
718	PT 17-113	-0.0205	NA	-0.0221	-0.0206	-0.0216	-0.0206	-0.0206
719	PT 32-113	-0.0395	-0.0390	-0.0306	-0.0367	-0.0380	-0.0306	-0.0374
720	PT 32-114	-0.0936	-0.0934	-0.0931	-0.0934	-0.0944	-0.0934	-0.0934
721	PT 27-115	-0.2064	NA	-0.2099	-0.2096	-0.2086	-0.2096	-0.2081
722	PT 114-115	-0.0136	NA	-0.0137	-0.0138	-0.0148	-0.0138	-0.0138
723	PT 68-116	-1.8400	-1.8256	-1.8444	-1.8291	-1.8321	-1.8444	-1.8310
724	PT 12-117	-0.2000	NA	-0.1996	-0.1997	-0.1996	-0.1996	-0.1986
725	PT 75-118	-0.3987	NA	-0.3958	-0.4000	-0.3980	-0.3970	-0.3970
726	PT 76-118	0.0687	NA	0.0667	0.0679	0.0669	0.0679	0.0664
727	QF 1-2	-0.1304	-0.1267	-0.1268	-0.1267	-0.1277	-0.1267	-0.1267
728	QF 1-3	-0.1706	NA	-0.1736	-0.1734	-0.1727	-0.1728	-0.1700
729	QF 4-5	-0.2679	NA	-0.2741	-0.2722	-0.2714	-0.2713	-0.2704
730	QF 3-5	-0.1449	-0.1483	-0.1494	-0.1483	-0.1493	-0.1484	-0.1483
731	QF 5-6	0.0411	0.0415	0.0472	0.0415	0.0460	0.0441	0.0460
732	QF 6-7	-0.0477	-0.0493	-0.0475	-0.0493	-0.0483	-0.0493	-0.0493
733	QF 8-9	-0.8973	NA	-0.9134	-0.9851	-0.9118	-0.9131	-0.9093
734	QF 8-5	1.2473	NA	1.2728	1.3475	1.2468	1.2715	1.2412
735	QF 9-10	-0.2443	-0.2443	-0.2547	-0.3233	-0.2453	-0.2547	-0.2443
736	QF 4-11	-0.0022	-0.0021	-0.0024	-0.0034	-0.0031	-0.0032	-0.0031
737	QF 5-11	0.0297	0.0290	0.0302	0.0290	0.0290	0.0290	0.0290
738	QF 11-12	-0.3514	NA	-0.3421	-0.3524	-0.3407	-0.3448	-0.3402
739	QF 2-12	-0.2001	-0.2066	-0.2122	-0.2150	-0.2102	-0.2122	-0.2081
740	QF 3-12	-0.1240	NA	-0.1256	-0.1266	-0.1257	-0.1258	-0.1250
741	QF 7-12	-0.0651	-0.0664	-0.0684	-0.0664	-0.0674	-0.0664	-0.0664
742	QF 11-13	0.1141	NA	0.1182	0.1096	0.1205	0.1184	0.1221
743	QF 12-14	0.0262	0.0261	0.0306	0.0261	0.0376	0.0306	0.0422
744	QF 13-15	-0.0384	NA	-0.0390	-0.0466	-0.0348	-0.0386	-0.0342
745	QF 14-15	0.0314	0.0323	0.0297	0.0195	0.0333	0.0305	0.0330
746	QF 12-16	0.0430	NA	0.0486	0.0371	0.0518	0.0494	0.0524
747	QF 15-17	-0.2427	NA	-0.2351	-0.2378	-0.2356	-0.2342	-0.2339
748	QF 16-17	-0.0368	NA	-0.0378	-0.0462	-0.0325	-0.0371	-0.0309

749	QF 17-18	0.2476	0.2400	0.2380	0.2400	0.2410	0.2400	0.2400
750	QF 18-19	0.1683	NA	0.1667	0.1651	0.1702	0.1652	0.1692
751	QF 19-20	0.0517	NA	0.0389	0.0463	0.0486	0.0384	0.0486
752	QF 15-19	0.1572	NA	0.1504	0.1484	0.1592	0.1524	0.1586
753	QF 20-21	0.0471	NA	0.0389	0.0417	0.0450	0.0383	0.0459
754	QF 21-22	-0.0210	-0.0214	-0.0224	-0.0211	-0.0211	-0.0216	-0.0211
755	QF 22-23	-0.0676	NA	-0.0698	-0.0624	-0.0683	-0.0675	-0.0674
756	QF 23-24	0.1042	0.1059	0.1090	0.1061	0.1049	0.1053	0.1059
757	QF 23-25	-0.2616	NA	-0.2582	-0.2833	-0.2675	-0.2615	-0.2675
758	QF 26-25	0.2158	NA	0.2069	0.2212	0.2202	0.2069	0.2212
759	QF 25-27	0.3006	NA	0.3012	0.2949	0.3084	0.3026	0.3079
760	QF 27-28	-0.0059	NA	-0.0008	0.0090	-0.0047	-0.0007	-0.0057
761	QF 28-29	-0.0657	-0.0639	-0.0629	-0.0639	-0.0629	-0.0639	-0.0639
762	QF 30-17	0.9297	0.9583	0.9584	0.9575	0.9573	0.9583	0.9583
763	QF 8-30	0.2815	NA	0.2778	0.2658	0.2943	0.2788	0.2963
764	QF 26-30	-0.1146	NA	-0.1033	-0.0949	-0.1042	-0.1020	-0.1057
765	QF 17-31	0.1152	0.1136	0.1006	0.1001	0.1126	0.1012	0.1120
766	QF 29-31	-0.0864	NA	-0.0834	-0.0876	-0.0885	-0.0819	-0.0875
767	QF 23-32	0.0505	0.0496	0.0507	0.0243	0.0510	0.0496	0.0517
768	QF 31-32	0.1240	NA	0.1154	0.1104	0.1204	0.1166	0.1232
769	QF 27-32	0.0176	NA	0.0176	0.0184	0.0166	0.0184	0.0185
770	QF 15-33	-0.0442	NA	-0.0552	-0.0652	-0.0515	-0.0540	-0.0504
771	QF 19-34	-0.1040	NA	-0.1143	-0.1254	-0.1111	-0.1137	-0.1116
772	QF 35-36	0.0404	NA	0.0374	0.0374	0.0398	0.0373	0.0393
773	QF 35-37	-0.1304	NA	-0.1267	-0.1284	-0.1297	-0.1282	-0.1282
774	QF 33-37	-0.1049	NA	-0.1131	-0.1245	-0.1096	-0.1132	-0.1115
775	QF 34-36	0.0470	0.0486	0.0507	0.0529	0.0496	0.0504	0.0486
776	QF 34-37	-0.4420	NA	-0.4093	-0.4115	-0.4303	-0.4180	-0.4255
777	QF 38-37	1.1360	NA	1.1137	1.0615	1.1269	1.1159	1.1253
778	QF 37-39	0.0298	NA	0.0341	0.0476	0.0303	0.0294	0.0294
779	QF 37-40	-0.0368	-0.0380	-0.0351	-0.0268	-0.0370	-0.0380	-0.0380
780	QF 30-38	0.1903	NA	0.1783	0.1690	0.1843	0.1785	0.1845
781	QF 39-40	-0.0870	-0.0899	-0.0899	-0.0899	-0.0889	-0.0899	-0.0899
782	QF 40-41	0.0119	0.0116	0.0135	0.0116	0.0126	0.0116	0.0116
783	QF 40-42	-0.0645	NA	-0.0616	-0.0552	-0.0631	-0.0620	-0.0627
784	QF 41-42	-0.0779	NA	-0.0746	-0.0651	-0.0761	-0.0744	-0.0752
785	QF 43-44	-0.0133	-0.0136	-0.0096	-0.0136	-0.0126	-0.0108	-0.0119
786	QF 34-43	0.0163	0.0169	0.0262	0.1120	0.0179	0.0262	0.0169
787	QF 44-45	0.0548	NA	0.0509	-0.0856	0.0572	0.0497	0.0589
788	QF 45-46	-0.0357	NA	-0.0364	-0.0144	-0.0314	-0.0365	-0.0308
789	QF 46-47	-0.0122	NA	-0.0119	-0.0025	-0.0113	-0.0120	-0.0111
790	QF 46-48	-0.0583	-0.0561	-0.0583	-0.0483	-0.0565	-0.0584	-0.0561

791	QF 47-49	-0.1084	NA	-0.1048	-0.0975	-0.1042	-0.1050	-0.1043
792	QF 42-49	0.0524	NA	0.0561	0.0650	0.0558	0.0567	0.0569
793	QF 42-49	0.0524	NA	0.0561	0.0650	0.0558	0.0567	0.0569
794	QF 45-49	-0.0208	-0.0209	-0.0205	0.0043	-0.0158	-0.0205	-0.0152
795	QF 48-49	0.0321	NA	0.0371	0.0317	0.0326	0.0371	0.0316
796	QF 49-50	0.1343	NA	0.1324	0.1326	0.1314	0.1324	0.1325
797	QF 49-51	0.2044	NA	0.1989	0.2100	0.2019	0.1988	0.2018
798	QF 51-52	0.0625	NA	0.0670	0.0675	0.0622	0.0648	0.0630
799	QF 52-53	0.0199	0.0198	0.0245	0.0261	0.0200	0.0235	0.0197
800	QF 53-54	-0.0555	NA	-0.0553	-0.0639	-0.0546	-0.0534	-0.0552
801	QF 49-54	0.1307	NA	0.1321	0.1349	0.1302	0.1319	0.1298
802	QF 49-54	0.1120	NA	0.1133	0.1159	0.1113	0.1131	0.1110
803	QF 54-55	0.0146	0.0147	0.0148	0.0147	0.0147	0.0150	0.0146
804	QF 54-56	0.0435	NA	0.0467	0.0433	0.0443	0.0467	0.0433
805	QF 55-56	-0.0582	NA	-0.0566	-0.0579	-0.0579	-0.0574	-0.0581
806	QF 56-57	-0.0910	-0.0938	-0.0903	-0.0616	-0.0947	-0.0903	-0.0938
807	QF 50-57	0.0914	0.0878	0.0956	0.1219	0.0888	0.0951	0.0882
808	QF 56-58	-0.0369	NA	-0.0443	-0.0396	-0.0380	-0.0443	-0.0377
809	QF 51-58	0.0316	0.0313	0.0367	0.0313	0.0323	0.0357	0.0313
810	QF 54-59	-0.0751	NA	-0.0769	-0.0756	-0.0746	-0.0757	-0.0736
811	QF 56-59	-0.0417	NA	-0.0435	-0.0425	-0.0412	-0.0425	-0.0404
812	QF 56-59	-0.0391	NA	-0.0409	-0.0399	-0.0385	-0.0398	-0.0376
813	QF 55-59	-0.0826	NA	-0.0846	-0.0832	-0.0821	-0.0834	-0.0811
814	QF 59-60	0.0357	0.0364	0.0370	0.0373	0.0354	0.0364	0.0351
815	QF 59-61	0.0503	NA	0.0512	0.0520	0.0497	0.0506	0.0491
816	QF 60-61	0.0852	NA	0.0811	0.0863	0.0843	0.0820	0.0801
817	QF 60-62	-0.0711	-0.0736	-0.0667	-0.0599	-0.0648	-0.0643	-0.0683
818	QF 61-62	-0.1386	NA	-0.1302	-0.1221	-0.1284	-0.1270	-0.1323
819	QF 63-59	0.6748	NA	0.6742	0.6735	0.6779	0.6758	0.6786
820	QF 63-64	-0.6748	NA	-0.6742	-0.6735	-0.6769	-0.6758	-0.6783
821	QF 64-61	0.1399	NA	0.1433	0.1442	0.1408	0.1434	0.1408
822	QF 38-65	-0.5763	NA	-0.5652	-0.5223	-0.5708	-0.5674	-0.5700
823	QF 64-65	-0.6649	-0.6705	-0.6682	-0.6705	-0.6695	-0.6701	-0.6705
824	QF 49-66	0.0433	NA	0.0437	0.0543	0.0427	0.0443	0.0424
825	QF 49-66	0.0433	NA	0.0437	0.0543	0.0427	0.0443	0.0424
826	QF 62-66	-0.1726	NA	-0.1737	-0.1755	-0.1736	-0.1746	-0.1732
827	QF 62-67	-0.1441	-0.1480	-0.1489	-0.1498	-0.1470	-0.1480	-0.1480
828	QF 65-66	0.7225	NA	0.7216	0.7146	0.7304	0.7216	0.7296
829	QF 66-67	0.1927	NA	0.1911	0.1953	0.1933	0.1940	0.1911
830	QF 65-68	-0.2243	-0.2251	-0.2384	-0.2926	-0.2261	-0.2384	-0.2251
831	QF 47-69	0.1163	0.1167	0.1132	0.1151	0.1142	0.1134	0.1138
832	QF 49-69	0.1065	NA	0.1030	0.1031	0.1037	0.1032	0.1034

833	QF 68-69	1.1282	NA	1.1044	1.0920	1.1157	1.1044	1.1111
834	QF 69-70	0.1607	NA	0.1601	0.1532	0.1632	0.1582	0.1650
835	QF 24-70	-0.0297	NA	-0.0281	-0.0286	-0.0301	-0.0294	-0.0304
836	QF 70-71	-0.1238	NA	-0.1377	-0.1565	-0.1261	-0.1350	-0.1238
837	QF 24-72	0.0331	NA	0.0312	0.0306	0.0316	0.0306	0.0321
838	QF 71-72	-0.0094	-0.0094	-0.0145	-0.0094	-0.0104	-0.0126	-0.0096
839	QF 71-73	-0.1074	-0.1068	-0.1164	-0.1406	-0.1078	-0.1155	-0.1068
840	QF 70-74	0.1289	NA	0.1375	0.1417	0.1318	0.1348	0.1306
841	QF 70-75	0.0994	NA	0.1086	0.1119	0.1022	0.1054	0.1014
842	QF 69-75	0.2049	0.2124	0.2151	0.2124	0.2114	0.2097	0.2124
843	QF 74-75	-0.0619	-0.0604	-0.0583	-0.0604	-0.0614	-0.0604	-0.0604
844	QF 76-77	-0.2104	-0.2104	-0.2194	-0.2273	-0.2181	-0.2177	-0.2192
845	QF 69-77	0.0678	NA	0.0670	0.0527	0.0671	0.0662	0.0671
846	QF 75-77	-0.0955	NA	-0.1015	-0.1064	-0.0996	-0.0989	-0.1002
847	QF 77-78	0.0661	NA	0.0303	0.0159	0.0378	0.0365	0.0420
848	QF 78-79	-0.1837	-0.1824	-0.1807	-0.1824	-0.1814	-0.1800	-0.1824
849	QF 77-80	-0.3741	NA	-0.3677	-0.3770	-0.3680	-0.3661	-0.3707
850	QF 77-80	-0.2055	NA	-0.2027	-0.2071	-0.2028	-0.2019	-0.2041
851	QF 79-80	-0.2958	NA	-0.2867	-0.2903	-0.2878	-0.2868	-0.2903
852	QF 68-81	-0.0461	NA	-0.0599	-0.1002	-0.0530	-0.0598	-0.0481
853	QF 81-80	0.7554	0.7379	0.7423	0.7010	0.7498	0.7425	0.7379
854	QF 77-82	0.1755	0.1758	0.1803	0.1801	0.1768	0.1761	0.1758
855	QF 82-83	0.2439	NA	0.2510	0.2459	0.2447	0.2491	0.2437
856	QF 83-84	0.1469	NA	0.1543	0.1496	0.1500	0.1492	0.1487
857	QF 83-85	0.1200	NA	0.1262	0.1221	0.1218	0.1219	0.1211
858	QF 84-85	0.0899	0.0895	0.0881	0.0895	0.0885	0.0895	0.0895
859	QF 85-86	-0.0735	NA	-0.0734	-0.0724	-0.0734	-0.0724	-0.0724
860	QF 86-87	-0.1509	-0.1557	-0.1524	-0.1520	-0.1530	-0.1520	-0.1521
861	QF 85-88	0.0760	0.0731	0.0763	0.0731	0.0743	0.0730	0.0737
862	QF 85-89	0.0068	NA	0.0058	0.0056	0.0063	0.0056	0.0059
863	QF 88-89	-0.0247	NA	-0.0274	-0.0229	-0.0232	-0.0229	-0.0231
864	QF 89-90	-0.0472	NA	-0.0483	-0.0482	-0.0474	-0.0474	-0.0471
865	QF 89-90	-0.0544	NA	-0.0562	-0.0561	-0.0546	-0.0546	-0.0539
866	QF 90-91	0.0442	NA	0.0393	0.0435	0.0462	0.0448	0.0466
867	QF 89-92	-0.0210	NA	-0.0249	-0.0175	-0.0207	-0.0229	-0.0201
868	QF 89-92	-0.0507	NA	-0.0518	-0.0494	-0.0507	-0.0512	-0.0504
869	QF 91-92	-0.0663	-0.0663	-0.0623	-0.0624	-0.0673	-0.0663	-0.0673
870	QF 92-93	-0.1166	-0.1143	-0.1092	-0.1143	-0.1133	-0.1143	-0.1143
871	QF 92-94	-0.1521	NA	-0.1592	-0.1562	-0.1540	-0.1531	-0.1529
872	QF 93-94	-0.1950	NA	-0.2187	-0.2065	-0.2035	-0.1997	-0.1994
873	QF 94-95	0.0901	0.0934	0.0952	0.0934	0.0944	0.0934	0.0934
874	QF 80-96	0.2107	NA	0.2107	0.2131	0.2096	0.2097	0.2104

875	QF 82-96	-0.0657	-0.0648	-0.0681	-0.0692	-0.0658	-0.0629	-0.0648
876	QF 94-96	-0.0982	NA	-0.0962	-0.0979	-0.0968	-0.0979	-0.0977
877	QF 80-97	0.2575	NA	0.2576	0.2615	0.2576	0.2581	0.2588
878	QF 80-98	0.0832	NA	0.0844	0.0819	0.0852	0.0843	0.0868
879	QF 80-99	0.0817	NA	0.0807	0.0768	0.0810	0.0799	0.0817
880	QF 92-100	-0.1653	-0.1713	-0.1681	-0.1713	-0.1640	-0.1649	-0.1634
881	QF 94-100	-0.5054	NA	-0.5013	-0.5252	-0.4954	-0.5013	-0.4944
882	QF 95-96	-0.2169	-0.2188	-0.2175	-0.2188	-0.2178	-0.2188	-0.2185
883	QF 96-97	-0.2016	NA	-0.2016	-0.2024	-0.1998	-0.1992	-0.1999
884	QF 98-100	0.0243	0.0238	0.0240	0.0205	0.0248	0.0239	0.0253
885	QF 99-100	-0.0459	-0.0467	-0.0427	-0.0436	-0.0405	-0.0407	-0.0389
886	QF 100-101	0.2290	0.2323	0.2412	0.2835	0.2313	0.2275	0.2323
887	QF 92-102	-0.0839	NA	-0.0782	-0.0554	-0.0795	-0.0824	-0.0782
888	QF 101-102	0.1013	0.1027	0.0986	0.0716	0.0979	0.1026	0.0950
889	QF 100-103	-0.2215	NA	-0.2210	-0.2161	-0.2170	-0.2208	-0.2158
890	QF 100-104	0.1065	NA	0.1039	0.1092	0.1057	0.1052	0.1066
891	QF 103-104	0.1387	NA	0.1362	0.1410	0.1369	0.1376	0.1376
892	QF 103-105	0.1285	NA	0.1262	0.1324	0.1270	0.1274	0.1275
893	QF 100-106	0.0948	0.0913	0.0915	0.0981	0.0934	0.0927	0.0933
894	QF 104-105	0.0263	NA	0.0265	0.0335	0.0272	0.0262	0.0262
895	QF 105-105	0.0388	NA	0.0347	0.0378	0.0357	0.0348	0.0326
896	QF 105-107	-0.0237	NA	-0.0250	-0.0184	-0.0256	-0.0247	-0.0254
897	QF 105-108	-0.1113	-0.1074	-0.1069	-0.1074	-0.1084	-0.1080	-0.1074
898	QF 106-107	-0.0373	NA	-0.0373	-0.0316	-0.0382	-0.0371	-0.0371
899	QF 108-109	-0.1092	-0.1134	-0.1113	-0.1108	-0.1118	-0.1134	-0.1134
900	QF 103-110	0.0835	NA	0.0827	0.0933	0.0809	0.0828	0.0805
901	QF 109-110	-0.1339	-0.1392	-0.1335	-0.1227	-0.1382	-0.1345	-0.1398

902	QF 110-111	0.0096	NA	0.0117	0.0391	0.0105	0.0095	0.0095
903	QF 110-112	-0.3061	NA	-0.2955	-0.3032	-0.3024	-0.2959	-0.3034
904	QF 17-113	0.0590	0.0566	0.0576	0.0566	0.0556	0.0644	0.0566
905	QF 32-113	-0.1780	NA	-0.1635	-0.1611	-0.1749	-0.1635	-0.1757
906	QF 32-114	0.0178	NA	0.0166	0.0176	0.0187	0.0177	0.0177
907	QF 27-115	0.0506	0.0516	0.0500	0.0516	0.0506	0.0516	0.0516
908	QF 114-115	0.0022	0.0021	0.0024	0.0021	0.0031	0.0021	0.0021
909	QF 68-116	-0.6636	NA	-0.6400	-0.6436	-0.6454	-0.6400	-0.6443
910	QF 12-117	0.0520	0.0529	0.0547	0.0529	0.0528	0.0529	0.0529
911	QF 75-118	0.2359	0.2421	0.2397	0.2421	0.2411	0.2421	0.2421
912	QF 76-118	-0.0969	-0.0995	-0.0965	-0.0990	-0.0985	-0.0995	-0.0987
913	QT 1-2	0.1101	NA	0.1064	0.1065	0.1072	0.1064	0.1062
914	QT 1-3	0.1688	NA	0.1721	0.1721	0.1712	0.1714	0.1684
915	QT 4-5	0.2749	NA	0.2813	0.2793	0.2784	0.2784	0.2774
916	QT 3-5	0.1728	NA	0.1775	0.1770	0.1770	0.1768	0.1761
917	QT 5-6	-0.0130	NA	-0.0193	-0.0131	-0.0184	-0.0161	-0.0183
918	QT 6-7	0.0451	NA	0.0449	0.0468	0.0457	0.0467	0.0467
919	QT 8-9	0.2443	NA	0.2547	0.3233	0.2463	0.2547	0.2447
920	QT 8-5	-0.9201	NA	-0.9463	-1.0185	-0.9213	-0.9448	-0.9157
921	QT 9-10	-0.5104	NA	-0.5073	-0.4525	-0.5224	-0.5070	-0.5224
922	QT 4-11	0.0135	NA	0.0137	0.0148	0.0141	0.0145	0.0140
923	QT 5-11	-0.0062	NA	-0.0066	-0.0053	-0.0059	-0.0054	-0.0060
924	QT 11-12	0.3513	0.3379	0.3419	0.3524	0.3405	0.3447	0.3399
925	QT 2-12	0.1942	NA	0.2070	0.2099	0.2048	0.2070	0.2027
926	QT 3-12	0.0886	NA	0.0903	0.0915	0.0902	0.0905	0.0895
927	QT 7-12	0.0576	NA	0.0609	0.0589	0.0599	0.0589	0.0589
928	QT 11-13	-0.1216	-0.1259	-0.1257	-0.1173	-0.1280	-0.1259	-0.1297
929	QT 12-14	-0.0414	NA	-0.0457	-0.0412	-0.0527	-0.0457	-0.0574
930	QT 13-15	-0.0204	-0.0202	-0.0198	-0.0122	-0.0242	-0.0202	-0.0248
931	QT 14-15	-0.0783	NA	-0.0767	-0.0667	-0.0803	-0.0775	-0.0800
932	QT 12-16	-0.0632	NA	-0.0687	-0.0572	-0.0719	-0.0695	-0.0725
933	QT 15-17	0.2522	0.2547	0.2452	0.2478	0.2448	0.2440	0.2431
934	QT 16-17	-0.0030	NA	-0.0018	0.0065	-0.0074	-0.0026	-0.0090
935	QT 17-18	-0.2240	NA	-0.2142	-0.2164	-0.2174	-0.2163	-0.2164
936	QT 18-19	-0.1755	-0.1723	-0.1738	-0.1723	-0.1774	-0.1723	-0.1764
937	QT 19-20	-0.0771	NA	-0.0646	-0.0717	-0.0740	-0.0642	-0.0740
938	QT 15-19	-0.1650	NA	-0.1582	-0.1563	-0.1669	-0.1602	-0.1663
939	QT 20-21	-0.0590	-0.0578	-0.0509	-0.0535	-0.0568	-0.0505	-0.0578
940	QT 21-22	0.0176	0.0179	0.0187	0.0179	0.0182	0.0179	0.0182

941	QT 22-23	0.0769	0.0749	0.0769	0.0696	0.0759	0.0749	0.0749
942	QT 23-24	-0.1524	NA	-0.1574	-0.1545	-0.1533	-0.1536	-0.1542
943	QT 23-25	0.3863	0.3793	0.3876	0.4135	0.3981	0.3922	0.3986
944	QT 26-25	-0.1864	-0.1919	-0.1782	-0.1919	-0.1909	-0.1782	-0.1919
945	QT 25-27	-0.1525	NA	-0.1516	-0.1427	-0.1550	-0.1516	-0.1548
946	QT 27-28	-0.0043	-0.0044	-0.0095	-0.0193	-0.0054	-0.0095	-0.0044
947	QT 28-29	0.0464	NA	0.0435	0.0445	0.0436	0.0445	0.0446
948	QT 30-17	-0.7010	NA	-0.7325	-0.7291	-0.7281	-0.7320	-0.7297
949	QT 8-30	-0.7542	-0.7834	-0.7517	-0.7405	-0.7697	-0.7526	-0.7716
950	QT 26-30	-0.3657	NA	-0.3850	-0.3860	-0.3729	-0.3842	-0.3708
951	QT 17-31	-0.1473	NA	-0.1329	-0.1328	-0.1447	-0.1334	-0.1442
952	QT 29-31	0.0792	0.0803	0.0761	0.0803	0.0813	0.0747	0.0803
953	QT 23-32	-0.0624	NA	-0.0638	-0.0364	-0.0626	-0.0626	-0.0635
954	QT 31-32	-0.1360	NA	-0.1281	-0.1230	-0.1325	-0.1291	-0.1353
955	QT 27-32	-0.0343	NA	-0.0343	-0.0351	-0.0333	-0.0350	-0.0351
956	QT 15-33	0.0149	NA	0.0261	0.0363	0.0223	0.0249	0.0212
957	QT 19-34	0.0460	0.0452	0.0565	0.0678	0.0531	0.0559	0.0537
958	QT 35-36	-0.0429	NA	-0.0400	-0.0400	-0.0423	-0.0398	-0.0418
959	QT 35-37	0.1243	0.1219	0.1205	0.1219	0.1235	0.1219	0.1219
960	QT 33-37	0.0746	0.0768	0.0829	0.0944	0.0792	0.0829	0.0811
961	QT 34-36	-0.0498	NA	-0.0536	-0.0559	-0.0526	-0.0534	-0.0516
962	QT 34-37	0.4429	NA	0.4101	0.4119	0.4313	0.4186	0.4261
963	QT 38-37	-0.8801	NA	-0.8581	-0.8032	-0.8701	-0.8603	-0.8679
964	QT 37-39	-0.0230	NA	-0.0282	-0.0429	-0.0252	-0.0235	-0.0238
965	QT 37-40	0.0296	NA	0.0272	0.0176	0.0284	0.0301	0.0298
966	QT 30-38	-0.5598	-0.5403	-0.5486	-0.5392	-0.5551	-0.5485	-0.5549
967	QT 39-40	0.0775	NA	0.0804	0.0803	0.0794	0.0804	0.0804
968	QT 40-41	-0.0221	NA	-0.0237	-0.0219	-0.0228	-0.0219	-0.0219
969	QT 40-42	0.0230	0.0221	0.0198	0.0131	0.0211	0.0201	0.0208
970	QT 41-42	0.0524	0.0527	0.0486	0.0388	0.0501	0.0484	0.0493
971	QT 43-44	-0.0379	NA	-0.0415	-0.0364	-0.0389	-0.0404	-0.0396
972	QT 34-43	-0.0567	NA	-0.0665	-0.1494	-0.0584	-0.0665	-0.0574
973	QT 44-45	-0.0662	NA	-0.0622	0.0746	-0.0687	-0.0612	-0.0704
974	QT 45-46	0.0212	NA	0.0215	-0.0003	0.0167	0.0217	0.0163
975	QT 46-47	-0.0079	-0.0080	-0.0084	-0.0176	-0.0090	-0.0083	-0.0091
976	QT 46-48	0.0142	NA	0.0141	0.0041	0.0122	0.0142	0.0119
977	QT 47-49	0.0928	NA	0.0892	0.0819	0.0886	0.0895	0.0886
978	QT 42-49	0.0037	0.0037	-0.0002	-0.0088	-0.0006	-0.0009	-0.0011
979	QT 42-49	0.0037	0.0038	-0.0002	-0.0088	-0.0006	-0.0009	-0.0011
980	QT 45-49	0.0231	NA	0.0220	-0.0023	0.0178	0.0223	0.0174
981	QT 48-49	-0.0393	-0.0388	-0.0443	-0.0388	-0.0398	-0.0443	-0.0388
982	QT 49-50	-0.1314	-0.1303	-0.1300	-0.1303	-0.1293	-0.1303	-0.1303

983	QT 49-51	-0.1740	-0.1775	-0.1676	-0.1775	-0.1707	-0.1676	-0.1710
984	QT 51-52	-0.0699	-0.0721	-0.0744	-0.0747	-0.0697	-0.0721	-0.0704
985	QT 52-53	-0.0545	NA	-0.0589	-0.0602	-0.0546	-0.0580	-0.0543
986	QT 53-54	0.0299	NA	0.0299	0.0387	0.0290	0.0279	0.0297
987	QT 49-54	-0.1560	-0.1577	-0.1568	-0.1586	-0.1552	-0.1566	-0.1549
988	QT 49-54	-0.1379	NA	-0.1387	-0.1403	-0.1371	-0.1384	-0.1368
989	QT 54-55	-0.0325	NA	-0.0327	-0.0325	-0.0327	-0.0329	-0.0326
990	QT 54-56	-0.0498	-0.0496	-0.0530	-0.0496	-0.0506	-0.0530	-0.0496
991	QT 55-56	0.0557	0.0538	0.0541	0.0555	0.0554	0.0549	0.0555
992	QT 56-57	0.0749	NA	0.0741	0.0452	0.0784	0.0741	0.0774
993	QT 50-57	-0.1049	NA	-0.1082	-0.1327	-0.1014	-0.1074	-0.1009
994	QT 56-58	0.0153	0.0153	0.0227	0.0181	0.0163	0.0227	0.0161
995	QT 51-58	-0.0453	NA	-0.0504	-0.0449	-0.0461	-0.0494	-0.0451
996	QT 54-59	0.0426	0.0432	0.0443	0.0432	0.0421	0.0432	0.0412
997	QT 56-59	0.0099	NA	0.0116	0.0107	0.0093	0.0106	0.0085
998	QT 56-59	0.0113	0.0113	0.0132	0.0122	0.0107	0.0120	0.0099
999	QT 55-59	0.0588	NA	0.0608	0.0595	0.0584	0.0596	0.0574
1000	QT 59-60	-0.0440	NA	-0.0451	-0.0447	-0.0434	-0.0444	-0.0431
1001	QT 59-61	-0.0463	-0.0476	-0.0470	-0.0468	-0.0457	-0.0464	-0.0450
1002	QT 60-61	-0.0823	-0.0831	-0.0785	-0.0831	-0.0821	-0.0794	-0.0779
1003	QT 60-62	0.0574	NA	0.0528	0.0461	0.0508	0.0504	0.0544
1004	QT 61-62	0.1320	NA	0.1237	0.1155	0.1220	0.1204	0.1259
1005	QT 63-59	-0.5702	-0.5856	-0.5688	-0.5664	-0.5736	-0.5703	-0.5746
1006	QT 63-64	0.5251	0.5083	0.5250	0.5263	0.5277	0.5267	0.5293
1007	QT 64-61	-0.1368	NA	-0.1400	-0.1409	-0.1377	-0.1402	-0.1378
1008	QT 38-65	-0.0837	NA	-0.0951	-0.1311	-0.0914	-0.0940	-0.0914
1009	QT 64-65	0.4006	NA	0.4065	0.4126	0.4068	0.4084	0.4078
1010	QT 49-66	0.0832	0.0853	0.0839	0.0743	0.0848	0.0832	0.0853
1011	QT 49-66	0.0832	NA	0.0839	0.0743	0.0848	0.0832	0.0853
1012	QT 62-66	0.1468	0.1514	0.1491	0.1514	0.1487	0.1500	0.1481
1013	QT 62-67	0.1215	NA	0.1266	0.1273	0.1242	0.1258	0.1252
1014	QT 65-66	-0.7055	-0.6965	-0.7047	-0.6979	-0.7131	-0.7047	-0.7124
1015	QT 66-67	-0.1915	-0.1917	-0.1889	-0.1917	-0.1904	-0.1917	-0.1883
1016	QT 65-68	-0.4185	NA	-0.4045	-0.3482	-0.4184	-0.4046	-0.4190
1017	QT 47-69	-0.1007	NA	-0.0977	-0.0983	-0.0987	-0.0978	-0.0981
1018	QT 49-69	-0.1206	-0.1240	-0.1174	-0.1165	-0.1182	-0.1176	-0.1177
1019	QT 68-69	-1.0364	-1.0038	-1.0153	-1.0038	-1.0264	-1.0153	-1.0219
1020	QT 69-70	-0.1398	NA	-0.1391	-0.1327	-0.1437	-0.1380	-0.1454
1021	QT 24-70	-0.0680	-0.0701	-0.0697	-0.0692	-0.0680	-0.0684	-0.0676
1022	QT 70-71	0.1168	NA	0.1309	0.1499	0.1191	0.1281	0.1168
1023	QT 24-72	-0.0798	-0.0776	-0.0782	-0.0776	-0.0786	-0.0776	-0.0790
1024	QT 71-72	-0.0315	NA	-0.0263	-0.0315	-0.0306	-0.0282	-0.0313

1025	QT 71-73	0.0965	NA	0.1056	0.1300	0.0969	0.1047	0.0959
1026	QT 70-74	-0.1542	-0.1599	-0.1625	-0.1665	-0.1570	-0.1599	-0.1559
1027	QT 70-75	-0.1317	NA	-0.1406	-0.1437	-0.1345	-0.1375	-0.1337
1028	QT 69-75	-0.1831	NA	-0.1924	-0.1896	-0.1898	-0.1877	-0.1906
1029	QT 74-75	0.0644	NA	0.0605	0.0627	0.0636	0.0626	0.0626
1030	QT 76-77	0.2439	NA	0.2540	0.2634	0.2522	0.2521	0.2534
1031	QT 69-77	-0.1380	-0.1372	-0.1379	-0.1240	-0.1382	-0.1372	-0.1381
1032	QT 75-77	0.0738	0.0760	0.0803	0.0857	0.0781	0.0775	0.0787
1033	QT 77-78	-0.0763	NA	-0.0404	-0.0262	-0.0479	-0.0466	-0.0521
1034	QT 78-79	0.1795	NA	0.1765	0.1782	0.1772	0.1758	0.1782
1035	QT 77-80	0.3753	NA	0.3692	0.3788	0.3692	0.3674	0.3721
1036	QT 77-80	0.2059	NA	0.2033	0.2079	0.2032	0.2024	0.2046
1037	QT 79-80	0.3108	0.2989	0.3020	0.3055	0.3030	0.3020	0.3055
1038	QT 68-81	-0.7554	NA	-0.7423	-0.7010	-0.7508	-0.7425	-0.7551
1039	QT 81-80	-0.7305	NA	-0.7178	-0.6786	-0.7251	-0.7180	-0.7138
1040	QT 77-82	-0.2528	NA	-0.2576	-0.2574	-0.2543	-0.2535	-0.2533
1041	QT 82-83	-0.2699	-0.2697	-0.2768	-0.2717	-0.2707	-0.2750	-0.2697
1042	QT 83-84	-0.1599	NA	-0.1670	-0.1621	-0.1629	-0.1622	-0.1614
1043	QT 83-85	-0.1229	NA	-0.1288	-0.1249	-0.1243	-0.1249	-0.1239
1044	QT 84-85	-0.0924	NA	-0.0906	-0.0927	-0.0909	-0.0921	-0.0923
1045	QT 85-86	0.0509	0.0497	0.0507	0.0497	0.0507	0.0497	0.0497
1046	QT 86-87	0.1102	0.1112	0.1118	0.1112	0.1122	0.1112	0.1112
1047	QT 85-88	-0.0753	NA	-0.0761	-0.0736	-0.0735	-0.0729	-0.0737
1048	QT 85-89	0.0373	NA	0.0381	0.0372	0.0382	0.0380	0.0375
1049	QT 88-89	0.0770	0.0756	0.0804	0.0756	0.0758	0.0756	0.0756
1050	QT 89-90	0.0581	NA	0.0598	0.0591	0.0586	0.0587	0.0581
1051	QT 89-90	0.0707	0.0725	0.0737	0.0725	0.0713	0.0716	0.0704
1052	QT 90-91	-0.0646	NA	-0.0597	-0.0640	-0.0667	-0.0652	-0.0671
1053	QT 89-92	0.1696	NA	0.1731	0.1639	0.1696	0.1702	0.1673
1054	QT 89-92	0.0729	NA	0.0740	0.0710	0.0730	0.0730	0.0721
1055	QT 91-92	0.0359	NA	0.0319	0.0319	0.0368	0.0359	0.0368
1056	QT 92-93	0.1250	NA	0.1173	0.1223	0.1212	0.1222	0.1222
1057	QT 92-94	0.1591	0.1633	0.1666	0.1633	0.1619	0.1601	0.1600
1058	QT 93-94	0.1944	NA	0.2191	0.2065	0.2042	0.1996	0.1995
1059	QT 94-95	-0.0931	NA	-0.0980	-0.0962	-0.0973	-0.0962	-0.0963
1060	QT 80-96	-0.2462	NA	-0.2463	-0.2485	-0.2454	-0.2454	-0.2460
1061	QT 82-96	0.0129	NA	0.0153	0.0163	0.0129	0.0100	0.0119
1062	QT 94-96	0.0798	0.0799	0.0776	0.0794	0.0782	0.0794	0.0791
1063	QT 80-97	-0.2719	NA	-0.2720	-0.2758	-0.2720	-0.2725	-0.2732
1064	QT 80-98	-0.1043	-0.1038	-0.1055	-0.1030	-0.1063	-0.1055	-0.1078
1065	QT 80-99	-0.1294	NA	-0.1286	-0.1248	-0.1289	-0.1277	-0.1295
1066	QT 92-100	0.1537	NA	0.1569	0.1604	0.1528	0.1533	0.1517

1067	QT 94-100	0.4581	0.4462	0.4536	0.4787	0.4472	0.4536	0.4462
1068	QT 95-96	0.2051	NA	0.2057	0.2070	0.2059	0.2070	0.2067
1069	QT 96-97	0.1819	0.1884	0.1818	0.1827	0.1799	0.1794	0.1800
1070	QT 98-100	-0.0730	NA	-0.0727	-0.0695	-0.0736	-0.0727	-0.0741
1071	QT 99-100	0.0279	NA	0.0246	0.0255	0.0224	0.0227	0.0209
1072	QT 100-101	-0.2513	NA	-0.2627	-0.3021	-0.2535	-0.2498	-0.2544
1073	QT 92-102	0.0813	NA	0.0755	0.0524	0.0769	0.0796	0.0755
1074	QT 101-102	-0.1113	NA	-0.1086	-0.0822	-0.1077	-0.1127	-0.1053
1075	QT 100-103	0.2436	0.2370	0.2421	0.2370	0.2380	0.2421	0.2370
1076	QT 100-104	-0.0941	NA	-0.0930	-0.0980	-0.0946	-0.0940	-0.0953
1077	QT 103-104	-0.1583	NA	-0.1565	-0.1610	-0.1571	-0.1577	-0.1577
1078	QT 103-105	-0.1348	NA	-0.1334	-0.1391	-0.1340	-0.1343	-0.1343
1079	QT 100-106	-0.0712	NA	-0.0698	-0.0758	-0.0713	-0.0704	-0.0710
1080	QT 104-105	-0.0261	-0.0260	-0.0263	-0.0332	-0.0270	-0.0260	-0.0260
1081	QT 105-105	-0.0515	-0.0506	-0.0476	-0.0506	-0.0485	-0.0476	-0.0454
1082	QT 105-107	-0.0055	NA	-0.0045	-0.0110	-0.0039	-0.0046	-0.0040
1083	QT 105-108	0.0992	NA	0.0947	0.0952	0.0963	0.0958	0.0952
1084	QT 106-107	0.0055	0.0053	0.0055	-0.0002	0.0063	0.0053	0.0053
1085	QT 108-109	0.1039	0.1055	0.1059	0.1055	0.1065	0.1081	0.1081
1086	QT 103-110	-0.0615	NA	-0.0618	-0.0718	-0.0596	-0.0614	-0.0593
1087	QT 109-110	0.1177	NA	0.1173	0.1063	0.1221	0.1183	0.1237
1088	QT 110-111	-0.0184	NA	-0.0208	-0.0480	-0.0196	-0.0186	-0.0186
1089	QT 110-112	0.2851	NA	0.2731	0.2812	0.2802	0.2736	0.2812
1090	QT 17-113	-0.0665	NA	-0.0650	-0.0641	-0.0631	-0.0719	-0.0641
1091	QT 32-113	0.1340	0.1336	0.1183	0.1157	0.1306	0.1183	0.1314
1092	QT 32-114	-0.0322	-0.0322	-0.0311	-0.0322	-0.0332	-0.0322	-0.0322

1093	QT 27-115	-0.0653	NA	-0.0646	-0.0663	-0.0652	-0.0662	-0.0662
1094	QT 114-115	-0.0047	NA	-0.0049	-0.0047	-0.0057	-0.0047	-0.0047
1095	QT 68-116	0.5132	0.4934	0.4895	0.4934	0.4944	0.4895	0.4934
1096	QT 12-117	-0.0800	#N/A	-0.0827	-0.0808	-0.0810	-0.0809	-0.0812
1097	QT 75-118	-0.2356	#N/A	-0.2395	-0.2415	-0.2407	-0.2417	-0.2417
1098	QT 76-118	0.0856	#N/A	0.0852	0.0877	0.0871	0.0882	0.0873

B.3.2 Presence of a Single Bad-data

Table B.11 IEEE 118 Bus System with a single bad-data (PF_5-6) in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				
				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	Vm-1	0.9550	NA	0.9520	0.9526	0.9567	0.9540	0.9570
2	Vm-2	0.9714	0.9687	0.9661	0.9687	0.9728	0.9701	0.9730
3	Vm-3	0.9677	0.9694	0.9644	0.9655	0.9696	0.9669	0.9698
4	Vm-4	0.9980	0.9888	0.9936	0.9963	1.0002	0.9976	1.0004
5	Vm-5	1.0020	0.9945	0.9976	1.0004	1.0042	1.0017	1.0044
6	Vm-6	0.9900	NA	0.9901	0.9883	0.9921	0.9895	0.9922
7	Vm-7	0.9893	NA	0.9872	0.9877	0.9914	0.9889	0.9915
8	Vm-8	1.0150	NA	1.0134	1.0160	1.0174	1.0153	1.0171
9	Vm-9	1.0429	1.0463	1.0423	1.0463	1.0454	1.0436	1.0452
10	Vm-10	1.0500	NA	1.0505	1.0555	1.0523	1.0508	1.0520
11	Vm-11	0.9851	NA	0.9816	0.9835	0.9874	0.9848	0.9876
12	Vm-12	0.9900	0.9828	0.9865	0.9884	0.9922	0.9896	0.9922
13	Vm-13	0.9683	NA	0.9651	0.9671	0.9703	0.9678	0.9703
14	Vm-14	0.9836	NA	0.9787	0.9820	0.9852	0.9829	0.9847
15	Vm-15	0.9700	0.9703	0.9711	0.9709	0.9713	0.9696	0.9709
16	Vm-16	0.9839	NA	0.9810	0.9829	0.9855	0.9830	0.9854
17	Vm-17	0.9951	1.0000	0.9970	0.9959	0.9961	0.9944	0.9955
18	Vm-18	0.9730	0.9768	0.9751	0.9742	0.9743	0.9727	0.9738
19	Vm-19	0.9620	NA	0.9637	0.9633	0.9632	0.9618	0.9628
20	Vm-20	0.9569	NA	0.9599	0.9591	0.9583	0.9583	0.9582
21	Vm-21	0.9577	0.9604	0.9611	0.9604	0.9591	0.9598	0.9592
22	Vm-22	0.9690	NA	0.9724	0.9718	0.9703	0.9711	0.9706
23	Vm-23	0.9995	1.0001	1.0027	1.0009	1.0001	1.0011	1.0005
24	Vm-24	0.9920	0.9873	0.9949	0.9933	0.9926	0.9936	0.9930

25	Vm-25	1.0500	1.0536	1.0538	1.0536	1.0520	1.0521	1.0521
26	Vm-26	1.0150	NA	1.0186	1.0186	1.0171	1.0167	1.0172
27	Vm-27	0.9680	0.9732	0.9712	0.9725	0.9695	0.9699	0.9690
28	Vm-28	0.9616	0.9598	0.9644	0.9647	0.9629	0.9629	0.9625
29	Vm-29	0.9632	0.9696	0.9661	0.9662	0.9645	0.9645	0.9640
30	Vm-30	0.9853	0.9891	0.9869	0.9871	0.9874	0.9858	0.9868
31	Vm-31	0.9670	NA	0.9699	0.9700	0.9683	0.9681	0.9678
32	Vm-32	0.9630	NA	0.9663	0.9674	0.9646	0.9648	0.9639
33	Vm-33	0.9709	NA	0.9737	0.9742	0.9731	0.9717	0.9725
34	Vm-34	0.9840	0.9922	0.9881	0.9903	0.9870	0.9862	0.9865
35	Vm-35	0.9805	NA	0.9845	0.9866	0.9834	0.9826	0.9830
36	Vm-36	0.9800	0.9866	0.9841	0.9862	0.9830	0.9821	0.9825
37	Vm-37	0.9907	0.9967	0.9946	0.9967	0.9935	0.9926	0.9930
38	Vm-38	0.9613	NA	0.9636	0.9641	0.9636	0.9624	0.9630
39	Vm-39	0.9700	NA	0.9726	0.9745	0.9727	0.9721	0.9726
40	Vm-40	0.9700	0.9747	0.9728	0.9747	0.9728	0.9723	0.9728
41	Vm-41	0.9668	NA	0.9694	0.9715	0.9696	0.9691	0.9696
42	Vm-42	0.9850	0.9796	0.9867	0.9876	0.9873	0.9866	0.9872
43	Vm-43	0.9771	NA	0.9792	0.9672	0.9798	0.9776	0.9796
44	Vm-44	0.9844	0.9748	0.9848	0.9748	0.9868	0.9844	0.9865
45	Vm-45	0.9864	0.9905	0.9868	0.9896	0.9885	0.9868	0.9881
46	Vm-46	1.0050	1.0054	1.0054	1.0054	1.0064	1.0054	1.0060
47	Vm-47	1.0171	NA	1.0173	1.0162	1.0182	1.0173	1.0179
48	Vm-48	1.0206	NA	1.0209	1.0191	1.0215	1.0210	1.0213
49	Vm-49	1.0250	1.0334	1.0251	1.0235	1.0258	1.0251	1.0257
50	Vm-50	1.0011	NA	1.0014	0.9999	1.0023	1.0015	1.0020
51	Vm-51	0.9669	0.9762	0.9674	0.9642	0.9677	0.9675	0.9678
52	Vm-52	0.9568	NA	0.9570	0.9538	0.9577	0.9572	0.9576
53	Vm-53	0.9460	0.9407	0.9454	0.9419	0.9468	0.9458	0.9468
54	Vm-54	0.9550	0.9515	0.9545	0.9521	0.9558	0.9546	0.9559
55	Vm-55	0.9520	NA	0.9515	0.9490	0.9527	0.9515	0.9528
56	Vm-56	0.9540	0.9511	0.9535	0.9511	0.9548	0.9536	0.9549
57	Vm-57	0.9706	0.9646	0.9699	0.9646	0.9716	0.9700	0.9716
58	Vm-58	0.9590	NA	0.9592	0.9564	0.9598	0.9593	0.9599
59	Vm-59	0.9850	0.9915	0.9849	0.9822	0.9856	0.9847	0.9856
60	Vm-60	0.9932	NA	0.9930	0.9903	0.9939	0.9929	0.9939
61	Vm-61	0.9950	NA	0.9948	0.9921	0.9957	0.9947	0.9958
62	Vm-62	0.9980	0.9923	0.9975	0.9945	0.9982	0.9972	0.9984
63	Vm-63	0.9687	0.9648	0.9687	0.9660	0.9694	0.9685	0.9694
64	Vm-64	0.9837	0.9782	0.9837	0.9810	0.9845	0.9836	0.9845
65	Vm-65	1.0050	NA	1.0051	1.0027	1.0060	1.0051	1.0060

66	Vm-66	1.0500	NA	1.0502	1.0478	1.0509	1.0501	1.0509
67	Vm-67	1.0197	NA	1.0198	1.0168	1.0203	1.0195	1.0204
68	Vm-68	1.0032	0.9981	1.0036	1.0021	1.0043	1.0035	1.0043
69	Vm-69	1.0350	1.0435	1.0362	1.0349	1.0365	1.0361	1.0367
70	Vm-70	0.9840	0.9887	0.9854	0.9849	0.9851	0.9855	0.9852
71	Vm-71	0.9868	0.9886	0.9888	0.9889	0.9880	0.9886	0.9881
72	Vm-72	0.9800	NA	0.9830	0.9818	0.9811	0.9821	0.9812
73	Vm-73	0.9910	0.9973	0.9933	0.9945	0.9922	0.9932	0.9922
74	Vm-74	0.9580	NA	0.9582	0.9571	0.9588	0.9587	0.9590
75	Vm-75	0.9673	0.9578	0.9672	0.9663	0.9681	0.9679	0.9681
76	Vm-76	0.9430	0.9415	0.9428	0.9415	0.9434	0.9431	0.9435
77	Vm-77	1.0060	1.0122	1.0073	1.0076	1.0077	1.0074	1.0079
78	Vm-78	1.0034	NA	1.0051	1.0056	1.0054	1.0051	1.0055
79	Vm-79	1.0092	NA	1.0109	1.0113	1.0111	1.0108	1.0113
80	Vm-80	1.0400	1.0495	1.0411	1.0418	1.0415	1.0411	1.0418
81	Vm-81	0.9968	NA	0.9974	0.9967	0.9979	0.9974	0.9979
82	Vm-82	0.9885	0.9897	0.9895	0.9897	0.9902	0.9899	0.9904
83	Vm-83	0.9844	NA	0.9851	0.9856	0.9861	0.9856	0.9863
84	Vm-84	0.9797	NA	0.9795	0.9811	0.9812	0.9807	0.9818
85	Vm-85	0.9850	0.9763	0.9848	0.9860	0.9867	0.9860	0.9869
86	Vm-86	0.9867	0.9875	0.9865	0.9875	0.9883	0.9875	0.9884
87	Vm-87	1.0150	NA	1.0152	1.0160	1.0170	1.0160	1.0169
88	Vm-88	0.9875	NA	0.9871	0.9885	0.9894	0.9886	0.9895
89	Vm-89	1.0050	NA	1.0050	1.0059	1.0068	1.0061	1.0069
90	Vm-90	0.9850	NA	0.9851	0.9861	0.9867	0.9860	0.9868
91	Vm-91	0.9800	0.9868	0.9806	0.9813	0.9817	0.9811	0.9818
92	Vm-92	0.9900	0.9806	0.9902	0.9908	0.9918	0.9912	0.9919
93	Vm-93	0.9854	NA	0.9850	0.9861	0.9870	0.9865	0.9872
94	Vm-94	0.9898	0.9921	0.9911	0.9912	0.9916	0.9911	0.9917
95	Vm-95	0.9803	NA	0.9814	0.9816	0.9819	0.9814	0.9820
96	Vm-96	0.9923	NA	0.9934	0.9937	0.9940	0.9935	0.9941
97	Vm-97	1.0112	NA	1.0123	1.0126	1.0127	1.0122	1.0128
98	Vm-98	1.0235	NA	1.0245	1.0254	1.0247	1.0245	1.0249
99	Vm-99	1.0100	NA	1.0113	1.0127	1.0115	1.0114	1.0117
100	Vm-100	1.0170	1.0221	1.0180	1.0195	1.0181	1.0180	1.0182
101	Vm-101	0.9914	0.9859	0.9910	0.9873	0.9924	0.9927	0.9923
102	Vm-102	0.9891	0.9915	0.9890	0.9883	0.9906	0.9902	0.9907
103	Vm-103	1.0100	1.0141	1.0110	1.0123	1.0109	1.0110	1.0109
104	Vm-104	0.9710	NA	0.9726	0.9731	0.9724	0.9723	0.9722
105	Vm-105	0.9650	0.9742	0.9666	0.9668	0.9663	0.9663	0.9662
106	Vm-106	0.9611	NA	0.9630	0.9630	0.9627	0.9627	0.9627

107	Vm-107	0.9520	0.9527	0.9538	0.9527	0.9537	0.9535	0.9535
108	Vm-108	0.9662	NA	0.9675	0.9677	0.9673	0.9673	0.9672
109	Vm-109	0.9670	NA	0.9684	0.9686	0.9682	0.9682	0.9681
110	Vm-110	0.9730	0.9825	0.9742	0.9736	0.9744	0.9742	0.9745
111	Vm-111	0.9800	0.9782	0.9810	0.9782	0.9813	0.9811	0.9814
112	Vm-112	0.9750	0.9667	0.9757	0.9756	0.9763	0.9757	0.9765
113	Vm-113	0.9930	0.9858	0.9948	0.9939	0.9941	0.9924	0.9935
114	Vm-114	0.9601	0.9645	0.9633	0.9645	0.9616	0.9619	0.9610
115	Vm-115	0.9600	NA	0.9633	0.9645	0.9615	0.9618	0.9609
116	Vm-116	1.0050	NA	1.0052	1.0037	1.0059	1.0052	1.0059
117	Vm-117	0.9738	NA	0.9685	0.9721	0.9759	0.9733	0.9760
118	Vm-118	0.9494	NA	0.9492	0.9481	0.9499	0.9497	0.9500
119	PG-1	-0.5100	NA	-0.5036	-0.5192	-0.5168	-0.5189	-0.5196
120	PG-2	-0.2000	NA	-0.1612	-0.2052	-0.2052	-0.2052	-0.2052
121	PG-3	-0.3900	-0.3849	-0.4198	-0.3849	-0.3839	-0.3849	-0.3834
122	PG-4	-0.3900	-0.3958	-0.3576	-0.3958	-0.3948	-0.3958	-0.3943
123	PG-5	0.0000	NA	-2.1459	0.0330	0.0220	0.0160	-0.0011
124	PG-6	-0.5200	NA	0.8022	-0.5150	-0.5106	-0.5119	-0.5120
125	PG-7	-0.1900	NA	-0.0117	-0.1991	-0.1991	-0.1968	-0.1991
126	PG-8	-0.2800	-0.2824	-0.2603	-0.2824	-0.2814	-0.2824	-0.2824
127	PG-9	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
128	PG-10	4.5000	NA	4.5039	4.4834	4.4826	4.4838	4.4837
129	PG-11	-0.7000	NA	-0.0912	-0.6996	-0.6976	-0.7038	-0.6956
130	PG-12	0.3800	0.3848	0.3953	0.3848	0.3858	0.3848	0.3842
131	PG-13	-0.3400	-0.3381	-0.3245	-0.3381	-0.3372	-0.3381	-0.3381
132	PG-14	-0.1400	NA	-0.0789	-0.1430	-0.1416	-0.1439	-0.1418
133	PG-15	-0.9000	-0.8950	-0.9149	-0.8968	-0.8960	-0.8953	-0.8950
134	PG-16	-0.2500	-0.2480	-0.2410	-0.2480	-0.2488	-0.2480	-0.2480
135	PG-17	-0.1100	NA	-0.1709	-0.0845	-0.0596	-0.0647	-0.0935
136	PG-18	-0.6000	NA	-0.6158	-0.6016	-0.5989	-0.6014	-0.6058
137	PG-19	-0.4500	-0.4509	-0.4664	-0.4509	-0.4499	-0.4509	-0.4509
138	PG-20	-0.1800	-0.1776	-0.1893	-0.1776	-0.1786	-0.1807	-0.1776
139	PG-21	-0.1400	NA	-0.1470	-0.1416	-0.1465	-0.1411	-0.1450
140	PG-22	-0.1000	NA	-0.0947	-0.0862	-0.0972	-0.0918	-0.0847
141	PG-23	-0.0700	NA	-0.1037	-0.0954	-0.1565	-0.1104	-0.1034
142	PG-24	-0.1300	-0.1323	-0.1334	-0.1323	-0.1324	-0.1323	-0.1308
143	PG-25	2.2000	2.2435	2.2406	2.2435	2.2425	2.2470	2.2435
144	PG-26	3.1400	NA	3.1427	3.1559	3.0698	3.1234	3.1606
145	PG-27	-0.7100	NA	-0.7095	-0.7192	-0.6829	-0.7105	-0.7167
146	PG-28	-0.1700	NA	-0.1745	-0.1738	-0.1738	-0.1770	-0.1738
147	PG-29	-0.2400	NA	-0.2355	-0.2378	-0.2387	-0.2369	-0.2382

148	PG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
149	PG-31	-0.3600	-0.3664	-0.3643	-0.3664	-0.3654	-0.3664	-0.3649
150	PG-32	-0.5900	NA	-0.6081	-0.6014	-0.5410	-0.6037	-0.5951
151	PG-33	-0.2300	-0.2314	-0.2463	-0.2386	-0.2324	-0.2320	-0.2314
152	PG-34	-0.5900	NA	-0.6288	-0.6017	-0.6108	-0.5973	-0.5980
153	PG-35	-0.3300	-0.3295	-0.3303	-0.3295	-0.3305	-0.3295	-0.3295
154	PG-36	-0.3100	-0.3044	-0.3052	-0.3044	-0.3054	-0.3044	-0.3044
155	PG-37	0.0000	NA	-0.0210	-0.0782	0.0283	-0.0203	-0.0333
156	PG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
157	PG-39	-0.2700	NA	-0.2611	-0.2549	-0.2702	-0.2632	-0.2609
158	PG-40	-0.6600	NA	-0.6517	-0.6478	-0.6547	-0.6519	-0.6511
159	PG-41	-0.3700	NA	-0.3698	-0.3677	-0.3655	-0.3676	-0.3683
160	PG-42	-0.9600	-0.9690	-0.9678	-0.9690	-0.9680	-0.9690	-0.9690
161	PG-43	-0.1800	NA	-0.1818	-0.1788	-0.1794	-0.1805	-0.1805
162	PG-44	-0.1600	-0.1581	-0.1598	-0.1581	-0.1571	-0.1581	-0.1581
163	PG-45	-0.5300	NA	-0.5201	-0.5330	-0.5178	-0.5253	-0.5325
164	PG-46	-0.0900	-0.0884	-0.0906	-0.0884	-0.0894	-0.0907	-0.0899
165	PG-47	-0.3400	-0.3455	-0.3434	-0.3455	-0.3445	-0.3455	-0.3440
166	PG-48	-0.2000	NA	-0.2022	-0.2004	-0.2050	-0.2008	-0.1998
167	PG-49	1.1700	1.1639	1.1635	1.1639	1.1629	1.1639	1.1624
168	PG-50	-0.1700	NA	-0.1562	-0.1474	-0.1483	-0.1504	-0.1534
169	PG-51	-0.1700	NA	-0.1763	-0.1739	-0.1773	-0.1730	-0.1704
170	PG-52	-0.1800	-0.1806	-0.1819	-0.1826	-0.1816	-0.1831	-0.1822
171	PG-53	-0.2300	-0.2321	-0.2327	-0.2321	-0.2331	-0.2321	-0.2336
172	PG-54	-0.6500	-0.6479	-0.6471	-0.6479	-0.6489	-0.6486	-0.6492
173	PG-55	-0.6300	-0.6404	-0.6380	-0.6404	-0.6394	-0.6404	-0.6389
174	PG-56	-0.8400	NA	-0.8289	-0.8205	-0.8279	-0.8290	-0.8326
175	PG-57	-0.1200	NA	-0.1295	-0.1376	-0.1369	-0.1323	-0.1340
176	PG-58	-0.1200	NA	-0.1220	-0.1215	-0.1215	-0.1221	-0.1220
177	PG-59	-1.2200	NA	-1.2306	-1.2570	-1.2308	-1.2304	-1.2119
178	PG-60	-0.7800	NA	-0.7590	-0.7776	-0.7355	-0.7588	-0.7434
179	PG-61	1.6000	1.5911	1.5827	1.5911	1.5901	1.5827	1.5896
180	PG-62	-0.7700	NA	-0.7961	-0.7707	-0.8189	-0.7963	-0.7971
181	PG-63	0.0000	NA	0.0000	0.0000	-0.0132	0.0000	-0.0216
182	PG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
183	PG-65	3.9100	NA	3.9526	3.9723	3.9262	3.9362	3.9391
184	PG-66	3.5300	3.5670	3.5606	3.5670	3.5660	3.5603	3.5655
185	PG-67	-0.2800	NA	-0.2853	-0.3030	-0.3086	-0.2856	-0.3013
186	PG-68	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
187	PG-69	5.1386	NA	5.1304	5.1264	5.1216	5.1274	5.1226
188	PG-70	-0.6600	-0.6498	-0.6506	-0.6498	-0.6508	-0.6498	-0.6513

189	PG-71	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
190	PG-72	-0.1200	NA	-0.1235	-0.1249	-0.1238	-0.1247	-0.1210
191	PG-73	-0.0600	NA	-0.0601	-0.0591	-0.0601	-0.0591	-0.0591
192	PG-74	-0.6800	NA	-0.6738	-0.6746	-0.6744	-0.6735	-0.6751
193	PG-75	-0.4700	NA	-0.4862	-0.4834	-0.4828	-0.4843	-0.4853
194	PG-76	-0.6800	NA	-0.6804	-0.6848	-0.6807	-0.6816	-0.6791
195	PG-77	-0.6100	-0.6014	-0.6011	-0.6014	-0.6004	-0.6014	-0.5999
196	PG-78	-0.7100	NA	-0.7270	-0.7190	-0.7245	-0.7249	-0.7271
197	PG-79	-0.3900	-0.3952	-0.3960	-0.3952	-0.3962	-0.3952	-0.3951
198	PG-80	3.4700	NA	3.5012	3.5024	3.4964	3.5006	3.4988
199	PG-81	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
200	PG-82	-0.5400	NA	-0.5428	-0.5489	-0.5469	-0.5435	-0.5491
201	PG-83	-0.2000	-0.2017	-0.1982	-0.2017	-0.2007	-0.1982	-0.2002
202	PG-84	-0.1100	NA	-0.1091	-0.0891	-0.1112	-0.1088	-0.0994
203	PG-85	-0.2400	-0.2384	-0.2348	-0.2384	-0.2374	-0.2348	-0.2369
204	PG-86	-0.2100	-0.2101	-0.2093	-0.2101	-0.2111	-0.2101	-0.2114
205	PG-87	0.0400	NA	0.0402	0.0398	0.0401	0.0398	0.0398
206	PG-88	-0.4800	NA	-0.4896	-0.4935	-0.4819	-0.4882	-0.4880
207	PG-89	6.0700	NA	6.0799	6.0620	6.0977	6.0763	6.0782
208	PG-90	-1.6300	-1.6414	-1.6428	-1.6414	-1.6424	-1.6414	-1.6429
209	PG-91	-0.1000	NA	-0.0966	-0.0909	-0.0969	-0.0997	-0.0944
210	PG-92	-0.6500	-0.6440	-0.6454	-0.6440	-0.6450	-0.6440	-0.6455
211	PG-93	-0.1200	NA	-0.1136	-0.1106	-0.0990	-0.1095	-0.1059
212	PG-94	-0.3000	NA	-0.3018	-0.3041	-0.3224	-0.3054	-0.3123
213	PG-95	-0.4200	NA	-0.4251	-0.4286	-0.4257	-0.4278	-0.4251
214	PG-96	-0.3800	-0.3754	-0.3769	-0.3754	-0.3764	-0.3754	-0.3769
215	PG-97	-0.1500	-0.1484	-0.1495	-0.1484	-0.1494	-0.1484	-0.1499
216	PG-98	-0.3400	-0.3426	-0.3398	-0.3426	-0.3416	-0.3398	-0.3411
217	PG-99	-0.4200	-0.4243	-0.4213	-0.4243	-0.4233	-0.4243	-0.4243
218	PG-100	2.1500	NA	2.1305	2.1360	2.1301	2.1374	2.1370
219	PG-101	-0.2200	NA	-0.2175	-0.2147	-0.2209	-0.2177	-0.2179
220	PG-102	-0.0500	-0.0491	-0.0506	-0.0491	-0.0501	-0.0491	-0.0506
221	PG-103	0.1700	NA	0.1625	0.1669	0.1672	0.1658	0.1659
222	PG-104	-0.3800	-0.3732	-0.3713	-0.3732	-0.3722	-0.3713	-0.3717
223	PG-105	-0.3100	-0.3093	-0.3087	-0.3093	-0.3095	-0.3093	-0.3093
224	PG-106	-0.4300	NA	-0.4214	-0.4250	-0.4244	-0.4250	-0.4251
225	PG-107	-0.5000	NA	-0.5010	-0.5025	-0.5002	-0.5025	-0.5024
226	PG-108	-0.0200	NA	-0.0225	-0.0224	-0.0227	-0.0224	-0.0224
227	PG-109	-0.0800	NA	-0.0741	-0.0736	-0.0754	-0.0743	-0.0758
228	PG-110	-0.3900	-0.3969	-0.3960	-0.3969	-0.3959	-0.3969	-0.3954
229	PG-111	0.3600	0.3566	0.3573	0.3566	0.3568	0.3566	0.3566

230	PG-112	-0.6800	-0.6720	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
231	PG-113	-0.0600	NA	-0.0520	-0.0573	-0.0600	-0.0512	-0.0580
232	PG-114	-0.0800	NA	-0.0792	-0.0797	-0.0797	-0.0797	-0.0797
233	PG-115	-0.2200	NA	-0.2239	-0.2234	-0.2234	-0.2234	-0.2219
234	PG-116	-1.8400	-1.8683	-1.8444	-1.8291	-1.8321	-1.8444	-1.8310
235	PG-117	-0.2000	-0.1997	-0.1939	-0.1997	-0.1996	-0.1996	-0.1986
236	PG-118	-0.3300	-0.3321	-0.3291	-0.3321	-0.3311	-0.3291	-0.3306
237	QG-1	-0.3010	NA	-0.2730	-0.3002	-0.3009	-0.2995	-0.2967
238	QG-2	-0.0900	NA	-0.1503	-0.1085	-0.1043	-0.1058	-0.1019
239	QG-3	-0.1000	-0.1028	-0.0815	-0.1028	-0.1038	-0.1028	-0.1048
240	QG-4	-0.2701	-0.2755	-0.2707	-0.2755	-0.2745	-0.2745	-0.2735
241	QG-5	0.0000	NA	0.2273	-0.0915	0.0019	-0.0152	0.0162
242	QG-6	-0.0607	NA	-0.1825	-0.0624	-0.0655	-0.0654	-0.0676
243	QG-7	-0.0200	NA	-0.1294	-0.0197	-0.0217	-0.0197	-0.0197
244	QG-8	0.6314	0.6283	0.6604	0.6283	0.6293	0.6372	0.6283
245	QG-9	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
246	QG-10	-0.5104	NA	-0.4751	-0.4525	-0.5228	-0.5070	-0.5224
247	QG-11	-0.2300	NA	-0.4194	-0.2332	-0.2166	-0.2173	-0.2100
248	QG-12	0.8129	0.8385	0.8116	0.8289	0.8375	0.8341	0.8385
249	QG-13	-0.1600	-0.1639	-0.1746	-0.1639	-0.1629	-0.1646	-0.1639
250	QG-14	-0.0100	NA	-0.0749	-0.0217	-0.0152	-0.0152	-0.0244
251	QG-15	-0.2284	-0.2335	-0.2239	-0.2335	-0.2325	-0.2335	-0.2305
252	QG-16	-0.1000	-0.1035	-0.1220	-0.1035	-0.1045	-0.1065	-0.1035
253	QG-17	-0.0300	NA	0.0347	-0.0781	-0.0863	-0.0927	-0.0870
254	QG-18	-0.0557	NA	-0.0400	-0.0513	-0.0477	-0.0511	-0.0472
255	QG-19	-0.3927	-0.4078	-0.3977	-0.4078	-0.4068	-0.4078	-0.4058
256	QG-20	-0.0300	-0.0301	-0.0236	-0.0301	-0.0291	-0.0258	-0.0281
257	QG-21	-0.0800	NA	-0.0747	-0.0747	-0.0793	-0.0720	-0.0789
258	QG-22	-0.0500	NA	-0.0510	-0.0444	-0.0482	-0.0495	-0.0492
259	QG-23	-0.0300	NA	-0.0247	-0.0832	-0.0418	-0.0317	-0.0350
260	QG-24	-0.1491	-0.1525	-0.1535	-0.1525	-0.1535	-0.1525	-0.1525
261	QG-25	0.5004	0.5166	0.5117	0.5166	0.5156	0.5166	0.5146
262	QG-26	0.1012	NA	0.1218	0.1263	0.0984	0.1049	0.1155
263	QG-27	-0.0902	NA	-0.0922	-0.0637	-0.1035	-0.0824	-0.0904
264	QG-28	-0.0700	NA	-0.0743	-0.0832	-0.0703	-0.0734	-0.0683
265	QG-29	-0.0400	NA	-0.0398	-0.0431	-0.0429	-0.0375	-0.0429
266	QG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	0.0004
267	QG-31	0.0559	0.0579	0.0579	0.0579	0.0582	0.0579	0.0593
268	QG-32	-0.3928	NA	-0.3790	-0.3380	-0.3982	-0.3736	-0.3919
269	QG-33	-0.0900	-0.0883	-0.0794	-0.0883	-0.0873	-0.0883	-0.0903
270	QG-34	-0.4683	NA	-0.4221	-0.3162	-0.4419	-0.4213	-0.4426

271	QG-35	-0.0900	-0.0909	-0.0896	-0.0909	-0.0899	-0.0909	-0.0889
272	QG-36	-0.0927	-0.0959	-0.0943	-0.0959	-0.0944	-0.0933	-0.0934
273	QG-37	0.0000	NA	0.0483	0.0942	-0.0039	0.0006	-0.0009
274	QG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
275	QG-39	-0.1100	NA	-0.1285	-0.1328	-0.1129	-0.1134	-0.1137
276	QG-40	0.0545	NA	0.0551	0.0544	0.0578	0.0601	0.0591
277	QG-41	-0.1000	NA	-0.0974	-0.0870	-0.1003	-0.0962	-0.0971
278	QG-42	0.1803	0.1818	0.1803	0.1818	0.1828	0.1818	0.1838
279	QG-43	-0.0700	NA	-0.0748	-0.1630	-0.0713	-0.0773	-0.0693
280	QG-44	-0.0800	-0.0780	-0.0870	-0.2171	-0.0790	-0.0875	-0.0780
281	QG-45	-0.2200	NA	-0.2204	-0.0334	-0.2194	-0.2157	-0.2141
282	QG-46	-0.1503	-0.1522	-0.1499	-0.1522	-0.1512	-0.1497	-0.1522
283	QG-47	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
284	QG-48	-0.1100	NA	-0.1056	-0.1200	-0.1116	-0.1050	-0.1129
285	QG-49	0.8585	0.8283	0.8333	0.8283	0.8293	0.8337	0.8283
286	QG-50	-0.0400	NA	-0.0347	-0.0084	-0.0404	-0.0352	-0.0420
287	QG-51	-0.0800	NA	-0.0644	-0.0787	-0.0758	-0.0671	-0.0767
288	QG-52	-0.0500	-0.0487	-0.0499	-0.0487	-0.0497	-0.0487	-0.0507
289	QG-53	-0.1100	-0.1082	-0.1144	-0.1241	-0.1092	-0.1114	-0.1095
290	QG-54	-0.2810	-0.2778	-0.2812	-0.2778	-0.2788	-0.2810	-0.2778
291	QG-55	-0.1734	-0.1737	-0.1740	-0.1737	-0.1727	-0.1737	-0.1717
292	QG-56	-0.2029	NA	-0.2185	-0.1777	-0.2087	-0.2149	-0.2035
293	QG-57	-0.0300	NA	-0.0342	-0.0876	-0.0226	-0.0333	-0.0235
294	QG-58	-0.0300	NA	-0.0277	-0.0268	-0.0298	-0.0267	-0.0290
295	QG-59	-0.3617	NA	-0.3502	-0.3515	-0.3669	-0.3580	-0.3735
296	QG-60	-0.0300	NA	-0.0306	-0.0183	-0.0240	-0.0269	-0.0313
297	QG-61	-0.4039	-0.3930	-0.3958	-0.3930	-0.3940	-0.3930	-0.3930
298	QG-62	-0.1274	NA	-0.1465	-0.1637	-0.1490	-0.1516	-0.1410
299	QG-63	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0003
300	QG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
301	QG-65	0.8151	NA	0.7861	0.7035	0.8089	0.7977	0.8209
302	QG-66	-0.1996	-0.2026	-0.1969	-0.2026	-0.2013	-0.1943	-0.2026
303	QG-67	-0.0700	NA	-0.0625	-0.0645	-0.0613	-0.0660	-0.0631
304	QG-68	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
305	QG-69	-0.8242	NA	-0.7896	-0.8003	-0.8008	-0.7966	-0.7932
306	QG-70	-0.1033	-0.1048	-0.1007	-0.1048	-0.1038	-0.1010	-0.1048
307	QG-71	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
308	QG-72	-0.1113	NA	-0.1042	-0.1091	-0.1080	-0.1058	-0.1103
309	QG-73	0.0965	NA	0.1051	0.1300	0.0969	0.1045	0.0959
310	QG-74	-0.3263	NA	-0.3318	-0.3368	-0.3283	-0.3307	-0.3267
311	QG-75	-0.1100	NA	-0.1354	-0.1351	-0.1180	-0.1194	-0.1198

312	QG-76	-0.3073	NA	-0.3160	-0.3264	-0.3162	-0.3172	-0.3179
313	QG-77	-0.1583	-0.1630	-0.1634	-0.1630	-0.1640	-0.1630	-0.1630
314	QG-78	-0.2600	NA	-0.2213	-0.2085	-0.2303	-0.2264	-0.2345
315	QG-79	-0.3200	-0.3166	-0.3145	-0.3166	-0.3156	-0.3154	-0.3166
316	QG-80	0.7947	NA	0.7908	0.8470	0.7856	0.7860	0.8062
317	QG-81	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0172
318	QG-82	-0.2700	NA	-0.2706	-0.2766	-0.2712	-0.2635	-0.2706
319	QG-83	-0.1000	-0.0972	-0.0933	-0.0972	-0.0962	-0.1010	-0.0972
320	QG-84	-0.0700	NA	-0.0790	-0.0726	-0.0743	-0.0727	-0.0719
321	QG-85	-0.2061	-0.2070	-0.2107	-0.2113	-0.2080	-0.2107	-0.2090
322	QG-86	-0.1000	-0.0989	-0.1017	-0.1023	-0.1023	-0.1023	-0.1023
323	QG-87	0.1102	NA	0.1118	0.1112	0.1122	0.1112	0.1112
324	QG-88	-0.1000	NA	-0.1035	-0.0965	-0.0960	-0.0959	-0.0968
325	QG-89	-0.0590	-0.0584	-0.0626	-0.0584	-0.0594	-0.0626	-0.0584
326	QG-90	0.1731	0.1751	0.1727	0.1751	0.1761	0.1751	0.1751
327	QG-91	-0.1309	NA	-0.1222	-0.1264	-0.1340	-0.1315	-0.1344
328	QG-92	-0.2396	-0.2305	-0.2357	-0.2305	-0.2315	-0.2357	-0.2325
329	QG-93	-0.0700	NA	-0.1017	-0.0842	-0.0822	-0.0775	-0.0772
330	QG-94	-0.1600	NA	-0.1164	-0.1599	-0.1314	-0.1461	-0.1392
331	QG-95	-0.3100	NA	-0.3156	-0.3150	-0.3151	-0.3150	-0.3148
332	QG-96	-0.1500	-0.1482	-0.1493	-0.1482	-0.1480	-0.1482	-0.1482
333	QG-97	-0.0900	-0.0931	-0.0904	-0.0931	-0.0921	-0.0931	-0.0931
334	QG-98	-0.0800	-0.0825	-0.0815	-0.0825	-0.0815	-0.0816	-0.0825
335	QG-99	-0.1754	-0.1684	-0.1713	-0.1684	-0.1694	-0.1684	-0.1684
336	QG-100	0.7755	NA	0.7779	0.8698	0.7626	0.7614	0.7611
337	QG-101	-0.1500	NA	-0.1642	-0.2304	-0.1555	-0.1471	-0.1594
338	QG-102	-0.0300	-0.0298	-0.0331	-0.0298	-0.0308	-0.0331	-0.0298
339	QG-103	0.5942	NA	0.5874	0.6036	0.5830	0.5899	0.5826
340	QG-104	-0.2261	-0.2255	-0.2231	-0.2255	-0.2245	-0.2255	-0.2268
341	QG-105	-0.4433	-0.4472	-0.4437	-0.4472	-0.4462	-0.4450	-0.4472
342	QG-106	-0.1600	NA	-0.1547	-0.1580	-0.1578	-0.1550	-0.1534
343	QG-107	-0.0544	NA	-0.0538	-0.0656	-0.0521	-0.0538	-0.0532
344	QG-108	-0.0100	NA	-0.0167	-0.0156	-0.0155	-0.0176	-0.0181
345	QG-109	-0.0300	NA	-0.0275	-0.0172	-0.0317	-0.0264	-0.0317
346	QG-110	-0.2972	-0.2865	-0.2853	-0.2865	-0.2863	-0.2865	-0.2865
347	QG-111	-0.0184	-0.0186	-0.0208	-0.0480	-0.0196	-0.0186	-0.0186
348	QG-112	0.2851	0.2812	0.2730	0.2812	0.2802	0.2735	0.2812
349	QG-113	0.0675	NA	0.0569	0.0515	0.0690	0.0554	0.0673
350	QG-114	-0.0300	NA	-0.0303	-0.0300	-0.0300	-0.0300	-0.0300
351	QG-115	-0.0700	NA	-0.0692	-0.0710	-0.0709	-0.0709	-0.0709
352	QG-116	0.5132	0.4975	0.4895	0.4934	0.4944	0.4895	0.4934

353	QG-117	-0.0800	-0.0800	-0.0939	-0.0808	-0.0810	-0.0809	-0.0812
354	QG-118	-0.1500	-0.1544	-0.1543	-0.1537	-0.1536	-0.1535	-0.1544
355	PF 1-2	-0.1235	-0.1248	-0.2076	-0.1248	-0.1238	-0.1248	-0.1248
356	PF 1-3	-0.3865	NA	-0.2959	-0.3945	-0.3931	-0.3942	-0.3948
357	PF 4-5	-1.0323	NA	-0.6230	-1.0377	-1.0357	-1.0377	-1.0347
358	PF 3-5	-0.6811	-0.6751	-0.5224	-0.6829	-0.6811	-0.6825	-0.6819
359	PF 5-6	0.8847	-0.8771	-0.1646	0.8858	0.8822	0.8827	0.8826
360	PF 6-7	0.3554	0.3614	0.6368	0.3614	0.3624	0.3614	0.3614
361	PF 8-9	-4.4064	NA	-4.4099	-4.3908	-4.3891	-4.3909	-4.3909
362	PF 8-5	3.3847	NA	3.4782	3.3606	3.3627	3.3740	3.3853
363	PF 9-10	-4.4525	-4.4367	-4.4563	-4.4367	-4.4357	-4.4367	-4.4367
364	PF 4-11	0.6423	0.6419	0.2655	0.6419	0.6409	0.6419	0.6404
365	PF 5-11	0.7722	0.7812	0.3428	0.7725	0.7713	0.7725	0.7706
366	PF 11-12	0.3429	NA	0.1246	0.3459	0.3448	0.3425	0.3458
367	PF 2-12	-0.3245	-0.3309	-0.3705	-0.3309	-0.3299	-0.3309	-0.3309
368	PF 3-12	-0.0979	NA	-0.1951	-0.0990	-0.0984	-0.0991	-0.0989
369	PF 7-12	0.1648	0.1617	0.6233	0.1617	0.1627	0.1640	0.1617
370	PF 11-13	0.3509	NA	0.3881	0.3481	0.3492	0.3474	0.3490
371	PF 12-14	0.1831	0.1837	0.2133	0.1837	0.1847	0.1837	0.1837
372	PF 13-15	0.0077	NA	0.0598	0.0069	0.0088	0.0062	0.0077
373	PF 14-15	0.0424	0.0422	0.1334	0.0399	0.0423	0.0390	0.0411
374	PF 12-16	0.0751	NA	0.1587	0.0716	0.0734	0.0705	0.0723
375	PF 15-17	-1.0386	NA	-0.9882	-1.0460	-1.0438	-1.0430	-1.0391
376	PF 16-17	-0.1751	NA	-0.0828	-0.1766	-0.1756	-0.1777	-0.1759
377	PF 17-18	0.8027	0.8065	0.8094	0.8065	0.8075	0.8065	0.8065
378	PF 18-19	0.1939	NA	0.1847	0.1961	0.1998	0.1963	0.1919
379	PF 19-20	-0.1062	NA	-0.0921	-0.1123	-0.0948	-0.1043	-0.1103
380	PF 15-19	0.1153	NA	0.1660	0.1133	0.1223	0.1170	0.1164
381	PF 20-21	-0.2867	NA	-0.2816	-0.2903	-0.2738	-0.2854	-0.2884
382	PF 21-22	-0.4284	-0.4366	-0.4302	-0.4337	-0.4219	-0.4282	-0.4351
383	PF 22-23	-0.5326	NA	-0.5291	-0.5241	-0.5231	-0.5241	-0.5241
384	PF 23-24	0.0828	0.0828	0.0809	0.0828	0.0818	0.0801	0.0828
385	PF 23-25	-1.6256	NA	-1.6509	-1.6481	-1.6534	-1.6525	-1.6520
386	PF 26-25	0.9029	NA	0.8970	0.9028	0.8679	0.8950	0.9013
387	PF 25-27	1.4352	NA	1.4436	1.4550	1.4136	1.4462	1.4495
388	PF 27-28	0.3288	NA	0.3294	0.3318	0.3328	0.3322	0.3318
389	PF 28-29	0.1566	0.1557	0.1527	0.1557	0.1567	0.1529	0.1557
390	PF 30-17	2.3119	2.2708	2.2456	2.3033	2.2718	2.2873	2.3038
391	PF 8-30	0.7416	NA	0.6714	0.7478	0.7450	0.7345	0.7232
392	PF 26-30	2.2371	NA	2.2457	2.2531	2.2019	2.2284	2.2593
393	PF 17-31	0.1477	0.1473	0.1569	0.1515	0.1483	0.1573	0.1509

394	PF 29-31	-0.0842	NA	-0.0834	-0.0828	-0.0827	-0.0846	-0.0832
395	PF 23-32	0.9298	0.9357	0.9270	0.9357	0.8819	0.9279	0.9316
396	PF 31-32	-0.2986	NA	-0.2930	-0.2996	-0.3019	-0.2958	-0.2993
397	PF 27-32	0.1253	NA	0.1294	0.1285	0.1265	0.1285	0.1270
398	PF 15-33	0.0731	NA	0.0989	0.0824	0.0763	0.0756	0.0762
399	PF 19-34	-0.0359	NA	-0.0250	-0.0305	-0.0344	-0.0346	-0.0336
400	PF 35-36	0.0084	NA	0.0090	0.0070	0.0083	0.0071	0.0070
401	PF 35-37	-0.3384	NA	-0.3393	-0.3366	-0.3388	-0.3366	-0.3366
402	PF 33-37	-0.1572	NA	-0.1478	-0.1566	-0.1564	-0.1567	-0.1555
403	PF 34-36	0.3025	0.2981	0.2971	0.2981	0.2979	0.2981	0.2981
404	PF 34-37	-0.9431	NA	-0.9642	-0.9451	-0.9587	-0.9447	-0.9443
405	PF 38-37	2.4337	NA	2.4557	2.4896	2.4260	2.4447	2.4523
406	PF 37-39	0.5491	NA	0.5413	0.5349	0.5518	0.5435	0.5411
407	PF 37-40	0.4402	0.4325	0.4364	0.4325	0.4428	0.4372	0.4357
408	PF 30-38	0.6235	NA	0.6286	0.6539	0.6321	0.6327	0.6345
409	PF 39-40	0.2692	0.2706	0.2706	0.2706	0.2716	0.2706	0.2706
410	PF 40-41	0.1545	0.1569	0.1575	0.1569	0.1579	0.1569	0.1569
411	PF 40-42	-0.1184	NA	-0.1152	-0.1143	-0.1116	-0.1141	-0.1147
412	PF 41-42	-0.2159	NA	-0.2127	-0.2112	-0.2080	-0.2110	-0.2117
413	PF 43-44	-0.1659	-0.1655	-0.1692	-0.1655	-0.1645	-0.1666	-0.1666
414	PF 34-43	0.0141	0.0140	0.0127	0.0140	0.0150	0.0140	0.0140
415	PF 44-45	-0.3277	NA	-0.3309	-0.3255	-0.3234	-0.3265	-0.3266
416	PF 45-46	-0.3633	NA	-0.3600	-0.3644	-0.3555	-0.3602	-0.3639
417	PF 46-47	-0.3111	NA	-0.3095	-0.3108	-0.3062	-0.3092	-0.3111
418	PF 46-48	-0.1476	-0.1475	-0.1464	-0.1475	-0.1439	-0.1470	-0.1481
419	PF 47-49	-0.0954	NA	-0.0959	-0.0972	-0.0955	-0.0978	-0.0975
420	PF 42-49	-0.6487	NA	-0.6493	-0.6487	-0.6453	-0.6485	-0.6492
421	PF 42-49	-0.6487	NA	-0.6493	-0.6487	-0.6453	-0.6485	-0.6492
422	PF 45-49	-0.4970	-0.4872	-0.4936	-0.4967	-0.4882	-0.4942	-0.4978
423	PF 48-49	-0.3490	NA	-0.3499	-0.3492	-0.3502	-0.3492	-0.3492
424	PF 49-50	0.5366	NA	0.5310	0.5281	0.5291	0.5281	0.5302
425	PF 49-51	0.6663	NA	0.6737	0.6746	0.6757	0.6733	0.6705
426	PF 51-52	0.2856	NA	0.2870	0.2885	0.2874	0.2885	0.2885
427	PF 52-53	0.1037	0.1033	0.1032	0.1040	0.1039	0.1035	0.1044
428	PF 53-54	-0.1268	NA	-0.1300	-0.1287	-0.1298	-0.1292	-0.1298
429	PF 49-54	0.3777	NA	0.3795	0.3812	0.3814	0.3802	0.3795
430	PF 49-54	0.3774	NA	0.3793	0.3811	0.3811	0.3800	0.3792
431	PF 54-55	0.0707	0.0714	0.0723	0.0732	0.0727	0.0727	0.0721
432	PF 54-56	0.1853	NA	0.1860	0.1864	0.1874	0.1864	0.1864
433	PF 55-56	-0.2142	NA	-0.2209	-0.2247	-0.2220	-0.2227	-0.2199
434	PF 56-57	-0.2299	-0.2260	-0.2285	-0.2260	-0.2270	-0.2285	-0.2260

435	PF 50-57	0.3588	0.3629	0.3671	0.3731	0.3732	0.3701	0.3691
436	PF 56-58	-0.0667	NA	-0.0640	-0.0659	-0.0649	-0.0653	-0.0654
437	PF 51-58	0.1879	0.1886	0.1872	0.1886	0.1876	0.1886	0.1886
438	PF 54-59	-0.3038	NA	-0.3030	-0.3007	-0.3028	-0.3032	-0.3052
439	PF 56-59	-0.2796	NA	-0.2791	-0.2770	-0.2788	-0.2791	-0.2807
440	PF 56-59	-0.2931	NA	-0.2926	-0.2903	-0.2922	-0.2926	-0.2943
441	PF 55-59	-0.3452	NA	-0.3448	-0.3426	-0.3447	-0.3451	-0.3470
442	PF 59-60	-0.4332	-0.4372	-0.4344	-0.4372	-0.4362	-0.4345	-0.4356
443	PF 59-61	-0.5172	NA	-0.5174	-0.5212	-0.5182	-0.5175	-0.5177
444	PF 60-61	-1.1207	NA	-1.1089	-1.1220	-1.0995	-1.1089	-1.1000
445	PF 60-62	-0.0987	-0.1004	-0.0907	-0.0992	-0.0784	-0.0907	-0.0852
446	PF 61-62	0.2549	NA	0.2625	0.2544	0.2775	0.2625	0.2676
447	PF 63-59	1.5177	NA	1.5248	1.5352	1.5210	1.5247	1.5122
448	PF 63-64	-1.5177	NA	-1.5248	-1.5352	-1.5343	-1.5247	-1.5338
449	PF 64-61	0.3054	NA	0.3187	0.3194	0.3177	0.3187	0.3083
450	PF 38-65	-1.8128	NA	-1.8296	-1.8383	-1.7955	-1.8146	-1.8202
451	PF 64-65	-1.8279	-1.8604	-1.8483	-1.8595	-1.8578	-1.8483	-1.8472
452	PF 49-66	-1.3222	NA	-1.3274	-1.3285	-1.3228	-1.3266	-1.3282
453	PF 49-66	-1.3222	NA	-1.3274	-1.3285	-1.3228	-1.3266	-1.3282
454	PF 62-66	-0.3716	NA	-0.3780	-0.3776	-0.3811	-0.3782	-0.3768
455	PF 62-67	-0.2430	-0.2387	-0.2472	-0.2387	-0.2397	-0.2472	-0.2387
456	PF 65-66	0.0854	NA	0.0821	0.0871	0.0861	0.0810	0.0851
457	PF 66-67	0.5316	NA	0.5414	0.5507	0.5573	0.5416	0.5489
458	PF 65-68	0.1418	0.1442	0.1499	0.1442	0.1452	0.1500	0.1442
459	PF 47-69	-0.5594	-0.5525	-0.5605	-0.5628	-0.5588	-0.5605	-0.5612
460	PF 49-69	-0.4654	NA	-0.4662	-0.4677	-0.4647	-0.4658	-0.4665
461	PF 68-69	-1.2580	NA	-1.2467	-1.2432	-1.2422	-1.2466	-1.2432
462	PF 69-70	1.0838	NA	1.0855	1.0841	1.0843	1.0841	1.0809
463	PF 24-70	-0.0622	NA	-0.0663	-0.0647	-0.0648	-0.0660	-0.0627
464	PF 70-71	0.1665	NA	0.1715	0.1704	0.1722	0.1716	0.1671
465	PF 24-72	0.0147	NA	0.0135	0.0149	0.0139	0.0135	0.0144
466	PF 71-72	0.1060	0.1072	0.1108	0.1107	0.1106	0.1119	0.1072
467	PF 71-73	0.0601	0.0592	0.0603	0.0592	0.0602	0.0592	0.0592
468	PF 70-74	0.1621	NA	0.1623	0.1634	0.1620	0.1621	0.1637
469	PF 70-75	-0.0013	NA	0.0005	0.0015	0.0002	0.0005	0.0021
470	PF 69-75	1.1001	1.1016	1.1026	1.1016	1.1026	1.1017	1.1016
471	PF 74-75	-0.5199	-0.5134	-0.5136	-0.5134	-0.5144	-0.5134	-0.5134
472	PF 76-77	-0.6115	-0.6192	-0.6139	-0.6172	-0.6141	-0.6139	-0.6129
473	PF 69-77	0.6221	NA	0.6191	0.6168	0.6195	0.6188	0.6194
474	PF 75-77	-0.3461	NA	-0.3491	-0.3503	-0.3488	-0.3487	-0.3483
475	PF 77-78	0.4539	NA	0.4682	0.4603	0.4669	0.4662	0.4685

476	PF 78-79	-0.2568	-0.2595	-0.2596	-0.2595	-0.2585	-0.2595	-0.2595
477	PF 77-80	-0.9657	NA	-0.9739	-0.9751	-0.9727	-0.9731	-0.9731
478	PF 77-80	-0.4437	NA	-0.4477	-0.4480	-0.4471	-0.4474	-0.4472
479	PF 79-80	-0.6474	NA	-0.6561	-0.6552	-0.6552	-0.6552	-0.6552
480	PF 68-81	-0.4415	NA	-0.4492	-0.4430	-0.4449	-0.4492	-0.4446
481	PF 81-80	-0.4420	-0.4435	-0.4498	-0.4435	-0.4445	-0.4497	-0.4450
482	PF 77-82	-0.0303	-0.0304	-0.0322	-0.0304	-0.0314	-0.0315	-0.0304
483	PF 82-83	-0.4722	NA	-0.4750	-0.4792	-0.4783	-0.4750	-0.4793
484	PF 83-84	-0.2479	NA	-0.2479	-0.2554	-0.2503	-0.2484	-0.2528
485	PF 83-85	-0.4277	NA	-0.4286	-0.4290	-0.4321	-0.4282	-0.4301
486	PF 84-85	-0.3635	-0.3682	-0.3628	-0.3503	-0.3672	-0.3628	-0.3580
487	PF 85-86	0.1717	NA	0.1708	0.1721	0.1728	0.1721	0.1734
488	PF 86-87	-0.0395	-0.0392	-0.0397	-0.0392	-0.0395	-0.0392	-0.0392
489	PF 85-88	-0.5039	-0.4945	-0.4990	-0.4946	-0.5070	-0.4998	-0.5000
490	PF 85-89	-0.7124	NA	-0.7114	-0.7084	-0.7161	-0.7114	-0.7116
491	PF 88-89	-0.9893	NA	-0.9939	-0.9933	-0.9943	-0.9933	-0.9933
492	PF 89-90	0.5822	NA	0.5850	0.5833	0.5855	0.5850	0.5847
493	PF 89-90	1.1083	NA	1.1138	1.1105	1.1146	1.1137	1.1130
494	PF 90-91	0.0141	NA	0.0092	0.0060	0.0110	0.0106	0.0082
495	PF 89-92	2.0154	NA	2.0138	2.0068	2.0223	2.0116	2.0137
496	PF 89-92	0.6359	NA	0.6354	0.6333	0.6381	0.6347	0.6354
497	PF 91-92	-0.0860	-0.0850	-0.0875	-0.0850	-0.0860	-0.0892	-0.0862
498	PF 92-93	0.5762	0.5728	0.5741	0.5728	0.5738	0.5728	0.5728
499	PF 92-94	0.5217	NA	0.5233	0.5229	0.5293	0.5233	0.5250
500	PF 93-94	0.4472	NA	0.4516	0.4533	0.4659	0.4543	0.4580
501	PF 94-95	0.4086	0.4122	0.4114	0.4122	0.4112	0.4122	0.4107
502	PF 80-96	0.1897	NA	0.1902	0.1912	0.1906	0.1906	0.1911
503	PF 82-96	-0.0994	-0.0979	-0.1014	-0.1015	-0.1014	-0.1015	-0.1016
504	PF 94-96	0.1979	NA	0.1978	0.1965	0.1972	0.1970	0.1971
505	PF 80-97	0.2642	NA	0.2645	0.2649	0.2648	0.2643	0.2655
506	PF 80-98	0.2895	NA	0.2900	0.2930	0.2914	0.2902	0.2912
507	PF 80-99	0.1956	NA	0.1966	0.1988	0.1976	0.1978	0.1980
508	PF 92-100	0.3150	0.3211	0.3162	0.3166	0.3191	0.3158	0.3164
509	PF 94-100	0.0428	NA	0.0438	0.0435	0.0440	0.0431	0.0430
510	PF 95-96	-0.0138	-0.0136	-0.0161	-0.0187	-0.0169	-0.0180	-0.0167
511	PF 96-97	-0.1110	NA	-0.1117	-0.1132	-0.1122	-0.1126	-0.1124
512	PF 98-100	-0.0526	-0.0517	-0.0519	-0.0517	-0.0522	-0.0517	-0.0519
513	PF 99-100	-0.2265	-0.2226	-0.2268	-0.2277	-0.2279	-0.2287	-0.2285
514	PF 100-101	-0.1674	-0.1698	-0.1694	-0.1698	-0.1708	-0.1698	-0.1698
515	PF 92-102	0.4465	NA	0.4467	0.4433	0.4511	0.4457	0.4475

516	PF 101-102	-0.3898	-0.3877	-0.3895	-0.3877	-0.3941	-0.3898	-0.3902
517	PF 100-103	1.2175	NA	1.2122	1.2135	1.2126	1.2136	1.2136
518	PF 100-104	0.5618	NA	0.5571	0.5586	0.5581	0.5583	0.5584
519	PF 103-104	0.3245	NA	0.3199	0.3220	0.3212	0.3211	0.3213
520	PF 103-105	0.4335	NA	0.4289	0.4315	0.4305	0.4307	0.4307
521	PF 100-106	0.6036	0.5930	0.5987	0.6008	0.6001	0.6007	0.6008
522	PF 104-105	0.4858	NA	0.4857	0.4871	0.4869	0.4879	0.4877
523	PF 105-105	0.0886	NA	0.0855	0.0877	0.0867	0.0877	0.0877
524	PF 105-107	0.2675	NA	0.2675	0.2686	0.2673	0.2686	0.2686
525	PF 105-108	0.2397	0.2396	0.2397	0.2396	0.2406	0.2396	0.2396
526	PF 106-107	0.2398	NA	0.2409	0.2413	0.2403	0.2413	0.2413
527	PF 108-109	0.2177	0.2154	0.2153	0.2154	0.2160	0.2154	0.2154
528	PF 103-110	0.6060	NA	0.6026	0.6037	0.6048	0.6043	0.6042
529	PF 109-110	0.1371	0.1389	0.1405	0.1411	0.1399	0.1404	0.1389
530	PF 110-111	-0.3570	NA	-0.3543	-0.3536	-0.3538	-0.3537	-0.3537
531	PF 110-112	0.6946	NA	0.6861	0.6862	0.6872	0.6861	0.6860
532	PF 17-113	0.0206	0.0206	0.0223	0.0206	0.0196	0.0206	0.0206
533	PF 32-113	0.0412	NA	0.0312	0.0380	0.0421	0.0319	0.0390
534	PF 32-114	0.0937	NA	0.0930	0.0936	0.0946	0.0936	0.0936
535	PF 27-115	0.2072	0.2104	0.2111	0.2104	0.2094	0.2104	0.2089
536	PF 114-115	0.0136	0.0138	0.0137	0.0138	0.0148	0.0138	0.0138
537	PF 68-116	1.8413	NA	1.8457	1.8304	1.8333	1.8457	1.8322
538	PF 12-117	0.2015	0.2001	0.1955	0.2012	0.2011	0.2011	0.2001
539	PF 75-118	0.4021	0.3946	0.3993	0.4035	0.4014	0.4004	0.4004
540	PF 76-118	-0.0685	-0.0676	-0.0666	-0.0676	-0.0666	-0.0676	-0.0661

541	PT 1-2	0.1245	NA	0.2092	0.1257	0.1247	0.1257	0.1257
542	PT 1-3	0.3890	NA	0.2977	0.3971	0.3956	0.3968	0.3974
543	PT 4-5	1.0343	NA	0.6239	1.0398	1.0377	1.0397	1.0367
544	PT 3-5	0.6935	NA	0.5302	0.6955	0.6935	0.6950	0.6942
545	PT 5-6	-0.8754	NA	0.1653	-0.8765	-0.8730	-0.8734	-0.8734
546	PT 6-7	-0.3548	NA	-0.6349	-0.3608	-0.3618	-0.3608	-0.3608
547	PT 8-9	4.4525	NA	4.4563	4.4367	4.4347	4.4367	4.4365
548	PT 8-5	-3.3847	NA	-3.4782	-3.3606	-3.3627	-3.3740	-3.3853
549	PT 9-10	4.5000	NA	4.5039	4.4834	4.4826	4.4838	4.4837
550	PT 4-11	-0.6336	NA	-0.2638	-0.6332	-0.6323	-0.6332	-0.6318
551	PT 5-11	-0.7602	NA	-0.3400	-0.7604	-0.7593	-0.7604	-0.7586
552	PT 11-12	-0.3415	-0.3444	-0.1240	-0.3444	-0.3434	-0.3410	-0.3444
553	PT 2-12	0.3273	NA	0.3741	0.3340	0.3329	0.3340	0.3339
554	PT 3-12	0.0989	NA	0.1973	0.1001	0.0995	0.1002	0.1000
555	PT 7-12	-0.1645	NA	-0.6197	-0.1614	-0.1624	-0.1637	-0.1614
556	PT 11-13	-0.3477	-0.3450	-0.3843	-0.3450	-0.3460	-0.3443	-0.3458
557	PT 12-14	-0.1824	NA	-0.2123	-0.1829	-0.1839	-0.1829	-0.1829
558	PT 13-15	-0.0077	-0.0078	-0.0594	-0.0069	-0.0088	-0.0062	-0.0077
559	PT 14-15	-0.0421	NA	-0.1323	-0.0397	-0.0420	-0.0387	-0.0408
560	PT 12-16	-0.0749	NA	-0.1581	-0.0714	-0.0732	-0.0703	-0.0721
561	PT 15-17	1.0544	1.0682	1.0028	1.0620	1.0597	1.0589	1.0549
562	PT 16-17	0.1766	NA	0.0833	0.1781	0.1770	0.1792	0.1773
563	PT 17-18	-0.7939	NA	-0.8005	-0.7977	-0.7987	-0.7977	-0.7977
564	PT 18-19	-0.1931	-0.1964	-0.1839	-0.1953	-0.1990	-0.1955	-0.1911
565	PT 19-20	0.1067	NA	0.0924	0.1127	0.0952	0.1047	0.1108
566	PT 15-19	-0.1147	NA	-0.1654	-0.1128	-0.1217	-0.1165	-0.1159
567	PT 20-21	0.2884	0.2920	0.2833	0.2920	0.2753	0.2870	0.2901
568	PT 21-22	0.4326	0.4249	0.4344	0.4379	0.4259	0.4323	0.4394
569	PT 22-23	0.5430	0.5341	0.5393	0.5341	0.5331	0.5341	0.5341
570	PT 23-24	-0.0825	NA	-0.0806	-0.0825	-0.0815	-0.0798	-0.0825
571	PT 23-25	1.6676	1.6958	1.6940	1.6913	1.6968	1.6958	1.6953
572	PT 26-25	-0.9029	-0.9028	-0.8970	-0.9028	-0.8679	-0.8950	-0.9013
573	PT 25-27	-1.3713	NA	-1.3793	-1.3899	-1.3516	-1.3815	-1.3844
574	PT 27-28	-0.3266	-0.3295	-0.3272	-0.3295	-0.3305	-0.3299	-0.3295
575	PT 28-29	-0.1558	NA	-0.1520	-0.1550	-0.1560	-0.1522	-0.1550
576	PT 30-17	-2.3119	NA	-2.2456	-2.3033	-2.2718	-2.2873	-2.3038
577	PT 8-30	-0.7381	-0.7443	-0.6685	-0.7443	-0.7415	-0.7310	-0.7197
578	PT 26-30	-2.1973	NA	-2.2057	-2.2129	-2.1635	-2.1890	-2.2188
579	PT 17-31	-0.1457	NA	-0.1550	-0.1497	-0.1464	-0.1554	-0.1490
580	PT 29-31	0.0843	0.0848	0.0836	0.0829	0.0829	0.0848	0.0834
581	PT 23-32	-0.9020	NA	-0.8995	-0.9078	-0.8569	-0.9002	-0.9037

582	PT 31-32	0.3020	NA	0.2962	0.3029	0.3053	0.2991	0.3028
583	PT 27-32	-0.1249	NA	-0.1290	-0.1281	-0.1261	-0.1281	-0.1266
584	PT 15-33	-0.0728	NA	-0.0985	-0.0821	-0.0760	-0.0753	-0.0759
585	PT 19-34	0.0365	0.0360	0.0257	0.0313	0.0350	0.0353	0.0342
586	PT 35-36	-0.0084	NA	-0.0090	-0.0070	-0.0083	-0.0070	-0.0070
587	PT 35-37	0.3399	0.3413	0.3408	0.3380	0.3403	0.3380	0.3380
588	PT 33-37	0.1586	0.1581	0.1492	0.1581	0.1579	0.1581	0.1570
589	PT 34-36	-0.3016	NA	-0.2962	-0.2973	-0.2971	-0.2973	-0.2973
590	PT 34-37	0.9459	NA	0.9671	0.9479	0.9616	0.9475	0.9471
591	PT 38-37	-2.4337	NA	-2.4557	-2.4896	-2.4260	-2.4447	-2.4523
592	PT 37-39	-0.5392	NA	-0.5316	-0.5255	-0.5418	-0.5338	-0.5315
593	PT 37-40	-0.4285	NA	-0.4249	-0.4213	-0.4310	-0.4257	-0.4243
594	PT 30-38	-0.6209	-0.6122	-0.6260	-0.6512	-0.6295	-0.6301	-0.6319
595	PT 39-40	-0.2676	NA	-0.2690	-0.2690	-0.2700	-0.2690	-0.2690
596	PT 40-41	-0.1541	NA	-0.1571	-0.1565	-0.1575	-0.1565	-0.1565
597	PT 40-42	0.1193	0.1197	0.1161	0.1151	0.1125	0.1150	0.1155
598	PT 41-42	0.2181	0.2177	0.2148	0.2132	0.2101	0.2131	0.2139
599	PT 43-44	0.1677	NA	0.1710	0.1673	0.1663	0.1684	0.1684
600	PT 34-43	-0.0141	NA	-0.0126	-0.0132	-0.0149	-0.0139	-0.0139
601	PT 44-45	0.3303	NA	0.3335	0.3281	0.3259	0.3291	0.3291
602	PT 45-46	0.3687	NA	0.3653	0.3699	0.3607	0.3655	0.3693
603	PT 46-47	0.3148	0.3201	0.3131	0.3144	0.3097	0.3128	0.3147
604	PT 46-48	0.1490	NA	0.1477	0.1488	0.1452	0.1484	0.1495
605	PT 47-49	0.0957	NA	0.0963	0.0975	0.0958	0.0982	0.0979
606	PT 42-49	0.6804	0.6887	0.6810	0.6804	0.6765	0.6802	0.6808
607	PT 42-49	0.6804	0.6755	0.6810	0.6804	0.6765	0.6802	0.6808
608	PT 45-49	0.5144	NA	0.5108	0.5140	0.5049	0.5114	0.5151
609	PT 48-49	0.3511	0.3514	0.3520	0.3514	0.3524	0.3514	0.3514
610	PT 49-50	-0.5288	-0.5205	-0.5233	-0.5205	-0.5215	-0.5205	-0.5225
611	PT 49-51	-0.6435	-0.6555	-0.6505	-0.6511	-0.6523	-0.6501	-0.6475
612	PT 51-52	-0.2837	-0.2866	-0.2851	-0.2866	-0.2855	-0.2866	-0.2866
613	PT 52-53	-0.1032	NA	-0.1027	-0.1035	-0.1034	-0.1029	-0.1038
614	PT 53-54	0.1274	NA	0.1305	0.1292	0.1303	0.1298	0.1304
615	PT 49-54	-0.3658	-0.3600	-0.3675	-0.3690	-0.3693	-0.3682	-0.3675
616	PT 49-54	-0.3638	NA	-0.3655	-0.3671	-0.3673	-0.3662	-0.3655
617	PT 54-55	-0.0706	NA	-0.0722	-0.0731	-0.0726	-0.0726	-0.0720
618	PT 54-56	-0.1852	-0.1863	-0.1859	-0.1863	-0.1873	-0.1863	-0.1863
619	PT 55-56	0.2145	0.2185	0.2212	0.2250	0.2223	0.2229	0.2201
620	PT 56-57	0.2321	NA	0.2307	0.2280	0.2292	0.2307	0.2281
621	PT 50-57	-0.3521	NA	-0.3601	-0.3656	-0.3661	-0.3631	-0.3621
622	PT 56-58	0.0669	0.0661	0.0642	0.0661	0.0651	0.0655	0.0656

623	PT 51-58	-0.1869	NA	-0.1862	-0.1876	-0.1866	-0.1876	-0.1876
624	PT 54-59	0.3090	0.3031	0.3082	0.3058	0.3080	0.3084	0.3104
625	PT 56-59	0.2867	NA	0.2862	0.2840	0.2858	0.2862	0.2879
626	PT 56-59	0.3007	0.3039	0.3002	0.2978	0.2998	0.3002	0.3019
627	PT 55-59	0.3516	NA	0.3512	0.3490	0.3511	0.3515	0.3535
628	PT 59-60	0.4394	NA	0.4407	0.4436	0.4425	0.4408	0.4419
629	PT 59-61	0.5264	0.5182	0.5266	0.5306	0.5275	0.5267	0.5269
630	PT 60-61	1.1241	1.1018	1.1122	1.1254	1.1028	1.1122	1.1033
631	PT 60-62	0.0989	NA	0.0909	0.0993	0.0786	0.0909	0.0853
632	PT 61-62	-0.2542	NA	-0.2618	-0.2538	-0.2767	-0.2618	-0.2669
633	PT 63-59	-1.5177	-1.5040	-1.5248	-1.5352	-1.5210	-1.5247	-1.5122
634	PT 63-64	1.5225	1.5402	1.5296	1.5402	1.5392	1.5296	1.5387
635	PT 64-61	-0.3054	NA	-0.3187	-0.3194	-0.3177	-0.3187	-0.3083
636	PT 38-65	1.8449	NA	1.8622	1.8711	1.8268	1.8467	1.8524
637	PT 64-65	1.8378	NA	1.8585	1.8698	1.8681	1.8585	1.8573
638	PT 49-66	1.3522	1.3473	1.3577	1.3589	1.3528	1.3568	1.3585
639	PT 49-66	1.3522	NA	1.3577	1.3589	1.3528	1.3568	1.3585
640	PT 62-66	0.3793	0.3833	0.3860	0.3856	0.3891	0.3862	0.3847
641	PT 62-67	0.2450	NA	0.2492	0.2406	0.2416	0.2492	0.2406
642	PT 65-66	-0.0854	-0.0871	-0.0821	-0.0871	-0.0861	-0.0810	-0.0851
643	PT 66-67	-0.5250	-0.5210	-0.5346	-0.5436	-0.5502	-0.5348	-0.5419
644	PT 65-68	-0.1418	NA	-0.1498	-0.1442	-0.1452	-0.1499	-0.1442
645	PT 47-69	0.5868	NA	0.5880	0.5905	0.5861	0.5880	0.5887
646	PT 49-69	0.4878	0.4913	0.4886	0.4903	0.4870	0.4882	0.4889
647	PT 68-69	1.2580	1.2432	1.2467	1.2432	1.2422	1.2466	1.2432
648	PT 69-70	-1.0494	NA	-1.0512	-1.0498	-1.0500	-1.0499	-1.0468
649	PT 24-70	0.0622	0.0617	0.0663	0.0648	0.0648	0.0660	0.0628
650	PT 70-71	-0.1661	NA	-0.1710	-0.1700	-0.1718	-0.1711	-0.1667
651	PT 24-72	-0.0145	-0.0148	-0.0133	-0.0148	-0.0138	-0.0134	-0.0143
652	PT 71-72	-0.1055	NA	-0.1102	-0.1102	-0.1100	-0.1113	-0.1067
653	PT 71-73	-0.0600	NA	-0.0601	-0.0591	-0.0601	-0.0591	-0.0591
654	PT 70-74	-0.1601	-0.1601	-0.1602	-0.1612	-0.1600	-0.1601	-0.1617
655	PT 70-75	0.0019	NA	0.0002	-0.0008	0.0004	0.0002	-0.0014
656	PT 69-75	-1.0516	NA	-1.0538	-1.0527	-1.0538	-1.0531	-1.0529
657	PT 74-75	0.5236	NA	0.5172	0.5170	0.5180	0.5169	0.5169
658	PT 76-77	0.6321	NA	0.6347	0.6385	0.6349	0.6348	0.6337
659	PT 69-77	-0.6105	-0.6042	-0.6077	-0.6054	-0.6080	-0.6073	-0.6079
660	PT 75-77	0.3541	0.3483	0.3573	0.3587	0.3570	0.3569	0.3565
661	PT 77-78	-0.4532	NA	-0.4674	-0.4595	-0.4660	-0.4654	-0.4676
662	PT 78-79	0.2574	NA	0.2601	0.2600	0.2590	0.2600	0.2600
663	PT 77-80	0.9834	NA	0.9917	0.9931	0.9905	0.9909	0.9910

664	PT 77-80	0.4505	NA	0.4545	0.4549	0.4540	0.4542	0.4541
665	PT 79-80	0.6550	0.6666	0.6639	0.6630	0.6629	0.6629	0.6629
666	PT 68-81	0.4420	NA	0.4498	0.4435	0.4455	0.4497	0.4452
667	PT 81-80	0.4420	NA	0.4498	0.4435	0.4445	0.4497	0.4450
668	PT 77-82	0.0317	NA	0.0336	0.0318	0.0328	0.0330	0.0318
669	PT 82-83	0.4756	0.4827	0.4784	0.4827	0.4817	0.4784	0.4827
670	PT 83-84	0.2535	NA	0.2537	0.2612	0.2560	0.2540	0.2586
671	PT 83-85	0.4367	NA	0.4377	0.4380	0.4412	0.4372	0.4391
672	PT 84-85	0.3679	NA	0.3672	0.3544	0.3717	0.3672	0.3623
673	PT 85-86	-0.1705	-0.1726	-0.1697	-0.1709	-0.1716	-0.1709	-0.1721
674	PT 86-87	0.0400	0.0398	0.0402	0.0398	0.0401	0.0398	0.0398
675	PT 85-88	0.5093	NA	0.5043	0.4998	0.5124	0.5051	0.5053
676	PT 85-89	0.7249	NA	0.7239	0.7207	0.7287	0.7239	0.7240
677	PT 88-89	1.0033	1.0074	1.0080	1.0074	1.0084	1.0074	1.0074
678	PT 89-90	-0.5648	NA	-0.5675	-0.5659	-0.5680	-0.5675	-0.5672
679	PT 89-90	-1.0793	-1.0881	-1.0846	-1.0815	-1.0855	-1.0846	-1.0840
680	PT 90-91	-0.0140	NA	-0.0091	-0.0059	-0.0109	-0.0105	-0.0081
681	PT 89-92	-1.9756	NA	-1.9740	-1.9674	-1.9824	-1.9720	-1.9741
682	PT 89-92	-0.6202	NA	-0.6196	-0.6177	-0.6223	-0.6190	-0.6197
683	PT 91-92	0.0864	NA	0.0879	0.0854	0.0864	0.0896	0.0866
684	PT 92-93	-0.5672	NA	-0.5652	-0.5639	-0.5649	-0.5639	-0.5639
685	PT 92-94	-0.5075	-0.5024	-0.5089	-0.5086	-0.5147	-0.5090	-0.5106
686	PT 93-94	-0.4418	NA	-0.4459	-0.4477	-0.4600	-0.4488	-0.4524
687	PT 94-95	-0.4062	NA	-0.4090	-0.4098	-0.4088	-0.4098	-0.4083
688	PT 80-96	-0.1866	NA	-0.1872	-0.1881	-0.1876	-0.1875	-0.1880
689	PT 82-96	0.0996	NA	0.1016	0.1017	0.1016	0.1017	0.1018
690	PT 94-96	-0.1966	-0.1949	-0.1965	-0.1953	-0.1959	-0.1957	-0.1958
691	PT 80-97	-0.2618	NA	-0.2621	-0.2625	-0.2624	-0.2619	-0.2631
692	PT 80-98	-0.2874	-0.2837	-0.2879	-0.2909	-0.2893	-0.2882	-0.2891
693	PT 80-99	-0.1935	NA	-0.1945	-0.1967	-0.1954	-0.1956	-0.1958
694	PT 92-100	-0.3071	NA	-0.3082	-0.3086	-0.3111	-0.3079	-0.3086
695	PT 94-100	-0.0387	-0.0390	-0.0398	-0.0390	-0.0400	-0.0390	-0.0390
696	PT 95-96	0.0145	NA	0.0169	0.0196	0.0177	0.0188	0.0175
697	PT 96-97	0.1118	0.1119	0.1126	0.1141	0.1130	0.1135	0.1132
698	PT 98-100	0.0528	NA	0.0521	0.0518	0.0524	0.0519	0.0521
699	PT 99-100	0.2274	NA	0.2278	0.2286	0.2288	0.2296	0.2294
700	PT 100-101	0.1698	NA	0.1720	0.1730	0.1732	0.1722	0.1722
701	PT 92-102	-0.4439	NA	-0.4441	-0.4408	-0.4485	-0.4431	-0.4449
702	PT 101-102	0.3939	NA	0.3936	0.3917	0.3983	0.3940	0.3943

703	PT 100-103	-1.1940	-1.1903	-1.1890	-1.1903	-1.1893	-1.1903	-1.1903
704	PT 100-104	-0.5473	NA	-0.5429	-0.5442	-0.5438	-0.5439	-0.5440
705	PT 103-104	-0.3185	NA	-0.3141	-0.3161	-0.3154	-0.3153	-0.3154
706	PT 103-105	-0.4225	NA	-0.4182	-0.4206	-0.4196	-0.4198	-0.4199
707	PT 100-106	-0.5814	NA	-0.5768	-0.5788	-0.5781	-0.5787	-0.5788
708	PT 104-105	-0.4833	-0.4854	-0.4832	-0.4846	-0.4844	-0.4854	-0.4852
709	PT 105-105	-0.0885	-0.0875	-0.0854	-0.0875	-0.0865	-0.0876	-0.0875
710	PT 105-107	-0.2635	NA	-0.2635	-0.2646	-0.2632	-0.2645	-0.2645
711	PT 105-108	-0.2377	NA	-0.2378	-0.2377	-0.2387	-0.2377	-0.2377
712	PT 106-107	-0.2365	-0.2379	-0.2375	-0.2379	-0.2369	-0.2379	-0.2379
713	PT 108-109	-0.2171	-0.2143	-0.2147	-0.2147	-0.2153	-0.2147	-0.2147
714	PT 103-110	-0.5915	NA	-0.5883	-0.5893	-0.5904	-0.5899	-0.5899
715	PT 109-110	-0.1361	NA	-0.1395	-0.1401	-0.1388	-0.1393	-0.1378
716	PT 110-111	0.3600	NA	0.3573	0.3566	0.3568	0.3566	0.3566
717	PT 110-112	-0.6800	NA	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
718	PT 17-113	-0.0205	NA	-0.0223	-0.0206	-0.0196	-0.0206	-0.0206
719	PT 32-113	-0.0395	-0.0390	-0.0298	-0.0367	-0.0404	-0.0306	-0.0374
720	PT 32-114	-0.0936	-0.0934	-0.0928	-0.0934	-0.0944	-0.0934	-0.0934
721	PT 27-115	-0.2064	NA	-0.2102	-0.2096	-0.2086	-0.2096	-0.2081
722	PT 114-115	-0.0136	NA	-0.0137	-0.0138	-0.0148	-0.0138	-0.0138
723	PT 68-116	-1.8400	-1.8256	-1.8444	-1.8291	-1.8321	-1.8444	-1.8310
724	PT 12-117	-0.2000	NA	-0.1939	-0.1997	-0.1996	-0.1996	-0.1986
725	PT 75-118	-0.3987	NA	-0.3959	-0.4000	-0.3980	-0.3970	-0.3970
726	PT 76-118	0.0687	NA	0.0668	0.0679	0.0669	0.0679	0.0664
727	QF 1-2	-0.1304	-0.1267	-0.0805	-0.1267	-0.1277	-0.1267	-0.1267
728	QF 1-3	-0.1706	NA	-0.1925	-0.1734	-0.1731	-0.1728	-0.1700

729	QF 4-5	-0.2679	NA	-0.3568	-0.2722	-0.2714	-0.2713	-0.2704
730	QF 3-5	-0.1449	-0.1483	-0.1793	-0.1483	-0.1493	-0.1484	-0.1483
731	QF 5-6	0.0411	0.0415	0.1689	0.0415	0.0448	0.0441	0.0460
732	QF 6-7	-0.0477	-0.0493	-0.0026	-0.0493	-0.0483	-0.0493	-0.0493
733	QF 8-9	-0.8973	NA	-0.9260	-0.9851	-0.9122	-0.9131	-0.9093
734	QF 8-5	1.2473	NA	1.3636	1.3475	1.2530	1.2715	1.2412
735	QF 9-10	-0.2443	-0.2443	-0.2787	-0.3233	-0.2453	-0.2547	-0.2443
736	QF 4-11	-0.0022	-0.0021	0.0861	-0.0034	-0.0031	-0.0032	-0.0031
737	QF 5-11	0.0297	0.0290	0.1262	0.0290	0.0290	0.0290	0.0290
738	QF 11-12	-0.3514	NA	-0.2868	-0.3524	-0.3441	-0.3448	-0.3402
739	QF 2-12	-0.2001	-0.2066	-0.2127	-0.2150	-0.2116	-0.2122	-0.2081
740	QF 3-12	-0.1240	NA	-0.0905	-0.1266	-0.1261	-0.1258	-0.1250
741	QF 7-12	-0.0651	-0.0664	-0.1352	-0.0664	-0.0674	-0.0664	-0.0664
742	QF 11-13	0.1141	NA	0.0989	0.1096	0.1193	0.1184	0.1221
743	QF 12-14	0.0262	0.0261	0.0363	0.0261	0.0333	0.0306	0.0422
744	QF 13-15	-0.0384	NA	-0.0703	-0.0466	-0.0360	-0.0386	-0.0342
745	QF 14-15	0.0314	0.0323	-0.0245	0.0195	0.0333	0.0305	0.0330
746	QF 12-16	0.0430	NA	0.0155	0.0371	0.0507	0.0494	0.0524
747	QF 15-17	-0.2427	NA	-0.2785	-0.2378	-0.2349	-0.2342	-0.2339
748	QF 16-17	-0.0368	NA	-0.0880	-0.0462	-0.0336	-0.0371	-0.0309
749	QF 17-18	0.2476	0.2400	0.2421	0.2400	0.2410	0.2400	0.2400
750	QF 18-19	0.1683	NA	0.1784	0.1651	0.1696	0.1652	0.1692
751	QF 19-20	0.0517	NA	0.0385	0.0463	0.0473	0.0384	0.0486
752	QF 15-19	0.1572	NA	0.1264	0.1484	0.1580	0.1524	0.1586
753	QF 20-21	0.0471	NA	0.0411	0.0417	0.0442	0.0383	0.0459
754	QF 21-22	-0.0210	-0.0214	-0.0212	-0.0211	-0.0224	-0.0216	-0.0211
755	QF 22-23	-0.0676	NA	-0.0687	-0.0624	-0.0665	-0.0675	-0.0674
756	QF 23-24	0.1042	0.1059	0.1115	0.1061	0.1049	0.1052	0.1059
757	QF 23-25	-0.2616	NA	-0.2638	-0.2833	-0.2713	-0.2615	-0.2675
758	QF 26-25	0.2158	NA	0.2148	0.2212	0.2182	0.2069	0.2212
759	QF 25-27	0.3006	NA	0.3045	0.2949	0.3034	0.3026	0.3079
760	QF 27-28	-0.0059	NA	-0.0017	0.0090	-0.0047	-0.0007	-0.0057
761	QF 28-29	-0.0657	-0.0639	-0.0656	-0.0639	-0.0649	-0.0639	-0.0639
762	QF 30-17	0.9297	0.9583	0.9179	0.9575	0.9573	0.9583	0.9583
763	QF 8-30	0.2815	NA	0.2228	0.2658	0.2884	0.2788	0.2963
764	QF 26-30	-0.1146	NA	-0.0930	-0.0949	-0.1197	-0.1020	-0.1057
765	QF 17-31	0.1152	0.1136	0.1065	0.1001	0.1133	0.1012	0.1120
766	QF 29-31	-0.0864	NA	-0.0859	-0.0876	-0.0885	-0.0819	-0.0875
767	QF 23-32	0.0505	0.0496	0.0509	0.0243	0.0506	0.0496	0.0517
768	QF 31-32	0.1240	NA	0.1181	0.1104	0.1224	0.1166	0.1232
769	QF 27-32	0.0176	NA	0.0159	0.0184	0.0166	0.0184	0.0185

770	QF 15-33	-0.0442	NA	-0.0651	-0.0652	-0.0522	-0.0540	-0.0504
771	QF 19-34	-0.1040	NA	-0.1167	-0.1254	-0.1117	-0.1137	-0.1116
772	QF 35-36	0.0404	NA	0.0389	0.0374	0.0392	0.0373	0.0393
773	QF 35-37	-0.1304	NA	-0.1285	-0.1284	-0.1292	-0.1282	-0.1282
774	QF 33-37	-0.1049	NA	-0.1159	-0.1245	-0.1102	-0.1132	-0.1115
775	QF 34-36	0.0470	0.0486	0.0498	0.0529	0.0496	0.0505	0.0486
776	QF 34-37	-0.4420	NA	-0.4223	-0.4115	-0.4268	-0.4177	-0.4255
777	QF 38-37	1.1360	NA	1.1007	1.0615	1.1275	1.1160	1.1253
778	QF 37-39	0.0298	NA	0.0442	0.0476	0.0307	0.0294	0.0294
779	QF 37-40	-0.0368	-0.0380	-0.0289	-0.0268	-0.0370	-0.0380	-0.0380
780	QF 30-38	0.1903	NA	0.1757	0.1690	0.1838	0.1785	0.1845
781	QF 39-40	-0.0870	-0.0899	-0.0899	-0.0899	-0.0889	-0.0899	-0.0899
782	QF 40-41	0.0119	0.0116	0.0143	0.0116	0.0126	0.0116	0.0116
783	QF 40-42	-0.0645	NA	-0.0602	-0.0552	-0.0640	-0.0620	-0.0627
784	QF 41-42	-0.0779	NA	-0.0729	-0.0651	-0.0775	-0.0744	-0.0752
785	QF 43-44	-0.0133	-0.0136	-0.0059	-0.0136	-0.0128	-0.0108	-0.0119
786	QF 34-43	0.0163	0.0169	0.0285	0.1120	0.0179	0.0262	0.0169
787	QF 44-45	0.0548	NA	0.0551	-0.0856	0.0572	0.0497	0.0589
788	QF 45-46	-0.0357	NA	-0.0363	-0.0144	-0.0339	-0.0366	-0.0308
789	QF 46-47	-0.0122	NA	-0.0120	-0.0025	-0.0116	-0.0120	-0.0111
790	QF 46-48	-0.0583	-0.0561	-0.0583	-0.0483	-0.0567	-0.0584	-0.0561
791	QF 47-49	-0.1084	NA	-0.1049	-0.0975	-0.1041	-0.1050	-0.1043
792	QF 42-49	0.0524	NA	0.0575	0.0650	0.0547	0.0566	0.0569
793	QF 42-49	0.0524	NA	0.0575	0.0650	0.0547	0.0566	0.0569
794	QF 45-49	-0.0208	-0.0209	-0.0204	0.0043	-0.0188	-0.0206	-0.0152
795	QF 48-49	0.0321	NA	0.0367	0.0317	0.0326	0.0371	0.0316
796	QF 49-50	0.1343	NA	0.1329	0.1326	0.1314	0.1324	0.1325
797	QF 49-51	0.2044	NA	0.1994	0.2100	0.2021	0.1988	0.2018
798	QF 51-52	0.0625	NA	0.0670	0.0675	0.0622	0.0648	0.0630
799	QF 52-53	0.0199	0.0198	0.0245	0.0261	0.0200	0.0235	0.0197
800	QF 53-54	-0.0555	NA	-0.0555	-0.0639	-0.0546	-0.0534	-0.0552
801	QF 49-54	0.1307	NA	0.1323	0.1349	0.1304	0.1319	0.1298
802	QF 49-54	0.1120	NA	0.1135	0.1159	0.1115	0.1131	0.1110
803	QF 54-55	0.0146	0.0147	0.0148	0.0147	0.0147	0.0150	0.0146
804	QF 54-56	0.0435	NA	0.0469	0.0433	0.0443	0.0467	0.0433
805	QF 55-56	-0.0582	NA	-0.0565	-0.0579	-0.0577	-0.0574	-0.0581
806	QF 56-57	-0.0910	-0.0938	-0.0903	-0.0616	-0.0948	-0.0903	-0.0938
807	QF 50-57	0.0914	0.0878	0.0958	0.1219	0.0888	0.0951	0.0882
808	QF 56-58	-0.0369	NA	-0.0442	-0.0396	-0.0380	-0.0443	-0.0377
809	QF 51-58	0.0316	0.0313	0.0366	0.0313	0.0323	0.0357	0.0313
810	QF 54-59	-0.0751	NA	-0.0770	-0.0756	-0.0748	-0.0757	-0.0736

811	QF 56-59	-0.0417	NA	-0.0437	-0.0425	-0.0416	-0.0425	-0.0404
812	QF 56-59	-0.0391	NA	-0.0411	-0.0399	-0.0390	-0.0398	-0.0376
813	QF 55-59	-0.0826	NA	-0.0847	-0.0832	-0.0824	-0.0834	-0.0811
814	QF 59-60	0.0357	0.0364	0.0370	0.0373	0.0354	0.0364	0.0351
815	QF 59-61	0.0503	NA	0.0511	0.0520	0.0497	0.0506	0.0491
816	QF 60-61	0.0852	NA	0.0811	0.0863	0.0844	0.0819	0.0801
817	QF 60-62	-0.0711	-0.0736	-0.0666	-0.0599	-0.0650	-0.0643	-0.0683
818	QF 61-62	-0.1386	NA	-0.1301	-0.1221	-0.1287	-0.1271	-0.1323
819	QF 63-59	0.6748	NA	0.6744	0.6735	0.6778	0.6759	0.6786
820	QF 63-64	-0.6748	NA	-0.6744	-0.6735	-0.6768	-0.6759	-0.6783
821	QF 64-61	0.1399	NA	0.1435	0.1442	0.1408	0.1435	0.1408
822	QF 38-65	-0.5763	NA	-0.5535	-0.5223	-0.5716	-0.5675	-0.5700
823	QF 64-65	-0.6649	-0.6705	-0.6686	-0.6705	-0.6695	-0.6701	-0.6705
824	QF 49-66	0.0433	NA	0.0437	0.0543	0.0420	0.0443	0.0424
825	QF 49-66	0.0433	NA	0.0437	0.0543	0.0420	0.0443	0.0424
826	QF 62-66	-0.1726	NA	-0.1739	-0.1755	-0.1733	-0.1746	-0.1732
827	QF 62-67	-0.1441	-0.1480	-0.1489	-0.1498	-0.1490	-0.1480	-0.1480
828	QF 65-66	0.7225	NA	0.7221	0.7146	0.7273	0.7216	0.7296
829	QF 66-67	0.1927	NA	0.1913	0.1953	0.1913	0.1940	0.1911
830	QF 65-68	-0.2243	-0.2251	-0.2382	-0.2926	-0.2261	-0.2384	-0.2251
831	QF 47-69	0.1163	0.1167	0.1132	0.1151	0.1141	0.1134	0.1138
832	QF 49-69	0.1065	NA	0.1031	0.1031	0.1036	0.1032	0.1034
833	QF 68-69	1.1282	NA	1.1046	1.0920	1.1154	1.1044	1.1111
834	QF 69-70	0.1607	NA	0.1587	0.1532	0.1642	0.1582	0.1650
835	QF 24-70	-0.0297	NA	-0.0263	-0.0286	-0.0309	-0.0294	-0.0304
836	QF 70-71	-0.1238	NA	-0.1392	-0.1565	-0.1261	-0.1348	-0.1238
837	QF 24-72	0.0331	NA	0.0327	0.0306	0.0306	0.0306	0.0321
838	QF 71-72	-0.0094	-0.0094	-0.0165	-0.0094	-0.0104	-0.0126	-0.0096
839	QF 71-73	-0.1074	-0.1068	-0.1159	-0.1406	-0.1078	-0.1153	-0.1068
840	QF 70-74	0.1289	NA	0.1386	0.1417	0.1312	0.1348	0.1306
841	QF 70-75	0.0994	NA	0.1096	0.1119	0.1017	0.1054	0.1014
842	QF 69-75	0.2049	0.2124	0.2151	0.2124	0.2114	0.2097	0.2124
843	QF 74-75	-0.0619	-0.0604	-0.0581	-0.0604	-0.0614	-0.0604	-0.0604
844	QF 76-77	-0.2104	-0.2104	-0.2194	-0.2273	-0.2177	-0.2177	-0.2192
845	QF 69-77	0.0678	NA	0.0672	0.0527	0.0672	0.0662	0.0671
846	QF 75-77	-0.0955	NA	-0.1014	-0.1064	-0.0994	-0.0989	-0.1002
847	QF 77-78	0.0661	NA	0.0304	0.0159	0.0388	0.0363	0.0420
848	QF 78-79	-0.1837	-0.1824	-0.1808	-0.1824	-0.1814	-0.1799	-0.1824
849	QF 77-80	-0.3741	NA	-0.3678	-0.3770	-0.3684	-0.3661	-0.3707
850	QF 77-80	-0.2055	NA	-0.2027	-0.2071	-0.2029	-0.2019	-0.2041
851	QF 79-80	-0.2958	NA	-0.2868	-0.2903	-0.2883	-0.2868	-0.2903

852	QF 68-81	-0.0461	NA	-0.0597	-0.1002	-0.0531	-0.0598	-0.0481
853	QF 81-80	0.7554	0.7379	0.7427	0.7010	0.7492	0.7425	0.7379
854	QF 77-82	0.1755	0.1758	0.1807	0.1801	0.1765	0.1762	0.1758
855	QF 82-83	0.2439	NA	0.2512	0.2459	0.2447	0.2490	0.2437
856	QF 83-84	0.1469	NA	0.1544	0.1496	0.1500	0.1492	0.1487
857	QF 83-85	0.1200	NA	0.1263	0.1221	0.1217	0.1219	0.1211
858	QF 84-85	0.0899	0.0895	0.0881	0.0895	0.0885	0.0895	0.0895
859	QF 85-86	-0.0735	NA	-0.0733	-0.0724	-0.0734	-0.0724	-0.0724
860	QF 86-87	-0.1509	-0.1557	-0.1524	-0.1520	-0.1530	-0.1520	-0.1521
861	QF 85-88	0.0760	0.0731	0.0763	0.0731	0.0741	0.0730	0.0737
862	QF 85-89	0.0068	NA	0.0058	0.0056	0.0064	0.0056	0.0059
863	QF 88-89	-0.0247	NA	-0.0274	-0.0229	-0.0227	-0.0229	-0.0231
864	QF 89-90	-0.0472	NA	-0.0482	-0.0482	-0.0474	-0.0474	-0.0471
865	QF 89-90	-0.0544	NA	-0.0561	-0.0561	-0.0544	-0.0546	-0.0539
866	QF 90-91	0.0442	NA	0.0393	0.0435	0.0462	0.0448	0.0466
867	QF 89-92	-0.0210	NA	-0.0249	-0.0175	-0.0205	-0.0229	-0.0201
868	QF 89-92	-0.0507	NA	-0.0518	-0.0494	-0.0507	-0.0512	-0.0504
869	QF 91-92	-0.0663	-0.0663	-0.0624	-0.0624	-0.0673	-0.0663	-0.0673
870	QF 92-93	-0.1166	-0.1143	-0.1091	-0.1143	-0.1133	-0.1143	-0.1143
871	QF 92-94	-0.1521	NA	-0.1593	-0.1562	-0.1540	-0.1531	-0.1529
872	QF 93-94	-0.1950	NA	-0.2189	-0.2065	-0.2035	-0.1997	-0.1994
873	QF 94-95	0.0901	0.0934	0.0951	0.0934	0.0944	0.0934	0.0934
874	QF 80-96	0.2107	NA	0.2109	0.2131	0.2096	0.2097	0.2104
875	QF 82-96	-0.0657	-0.0648	-0.0680	-0.0692	-0.0658	-0.0629	-0.0648
876	QF 94-96	-0.0982	NA	-0.0964	-0.0979	-0.0968	-0.0979	-0.0977
877	QF 80-97	0.2575	NA	0.2579	0.2615	0.2576	0.2581	0.2588
878	QF 80-98	0.0832	NA	0.0846	0.0819	0.0852	0.0844	0.0868
879	QF 80-99	0.0817	NA	0.0809	0.0768	0.0811	0.0799	0.0817
880	QF 92-100	-0.1653	-0.1713	-0.1682	-0.1713	-0.1640	-0.1649	-0.1634
881	QF 94-100	-0.5054	NA	-0.5012	-0.5252	-0.4953	-0.5013	-0.4944
882	QF 95-96	-0.2169	-0.2188	-0.2177	-0.2188	-0.2178	-0.2188	-0.2185
883	QF 96-97	-0.2016	NA	-0.2017	-0.2024	-0.1997	-0.1993	-0.1999
884	QF 98-100	0.0243	0.0238	0.0242	0.0205	0.0248	0.0239	0.0253
885	QF 99-100	-0.0459	-0.0467	-0.0425	-0.0436	-0.0405	-0.0407	-0.0389
886	QF 100-101	0.2290	0.2323	0.2413	0.2835	0.2313	0.2274	0.2323
887	QF 92-102	-0.0839	NA	-0.0781	-0.0554	-0.0795	-0.0824	-0.0782
888	QF 101-102	0.1013	0.1027	0.0986	0.0716	0.0980	0.1027	0.0950
889	QF 100-103	-0.2215	NA	-0.2209	-0.2161	-0.2169	-0.2208	-0.2158

890	QF 100-104	0.1065	NA	0.1040	0.1092	0.1058	0.1052	0.1066
891	QF 103-104	0.1387	NA	0.1362	0.1410	0.1370	0.1376	0.1376
892	QF 103-105	0.1285	NA	0.1263	0.1324	0.1271	0.1274	0.1275
893	QF 100-106	0.0948	0.0913	0.0916	0.0981	0.0934	0.0927	0.0933
894	QF 104-105	0.0263	NA	0.0266	0.0335	0.0272	0.0262	0.0262
895	QF 105-105	0.0388	NA	0.0348	0.0378	0.0355	0.0348	0.0326
896	QF 105-107	-0.0237	NA	-0.0249	-0.0184	-0.0256	-0.0247	-0.0254
897	QF 105-108	-0.1113	-0.1074	-0.1068	-0.1074	-0.1084	-0.1080	-0.1074
898	QF 106-107	-0.0373	NA	-0.0373	-0.0316	-0.0382	-0.0371	-0.0371
899	QF 108-109	-0.1092	-0.1134	-0.1113	-0.1108	-0.1118	-0.1134	-0.1134
900	QF 103-110	0.0835	NA	0.0828	0.0933	0.0809	0.0828	0.0805
901	QF 109-110	-0.1339	-0.1392	-0.1335	-0.1227	-0.1382	-0.1345	-0.1398
902	QF 110-111	0.0096	NA	0.0117	0.0391	0.0105	0.0095	0.0095
903	QF 110-112	-0.3061	NA	-0.2955	-0.3032	-0.3023	-0.2959	-0.3034
904	QF 17-113	0.0590	0.0566	0.0596	0.0566	0.0556	0.0566	0.0566
905	QF 32-113	-0.1780	NA	-0.1690	-0.1611	-0.1764	-0.1646	-0.1757
906	QF 32-114	0.0178	NA	0.0182	0.0176	0.0187	0.0177	0.0177
907	QF 27-115	0.0506	0.0516	0.0495	0.0516	0.0506	0.0516	0.0516
908	QF 114-115	0.0022	0.0021	0.0024	0.0021	0.0031	0.0021	0.0021
909	QF 68-116	-0.6636	NA	-0.6400	-0.6436	-0.6453	-0.6400	-0.6443
910	QF 12-117	0.0520	0.0529	0.0662	0.0529	0.0528	0.0529	0.0529
911	QF 75-118	0.2359	0.2421	0.2398	0.2421	0.2411	0.2421	0.2421
912	QF 76-118	-0.0969	-0.0995	-0.0966	-0.0990	-0.0985	-0.0995	-0.0987
913	QT 1-2	0.1101	NA	0.0625	0.1065	0.1072	0.1064	0.1062
914	QT 1-3	0.1688	NA	0.1883	0.1721	0.1716	0.1714	0.1684
915	QT 4-5	0.2749	NA	0.3589	0.2793	0.2784	0.2784	0.2774
916	QT 3-5	0.1728	NA	0.1868	0.1770	0.1771	0.1768	0.1761

917	QT 5-6	-0.0130	NA	-0.1799	-0.0131	-0.0171	-0.0161	-0.0183
918	QT 6-7	0.0451	NA	0.0058	0.0468	0.0457	0.0467	0.0467
919	QT 8-9	0.2443	NA	0.2788	0.3233	0.2463	0.2547	0.2447
920	QT 8-5	-0.9201	NA	-1.0115	-1.0185	-0.9307	-0.9448	-0.9157
921	QT 9-10	-0.5104	NA	-0.4751	-0.4525	-0.5228	-0.5070	-0.5224
922	QT 4-11	0.0135	NA	-0.0976	0.0148	0.0141	0.0145	0.0140
923	QT 5-11	-0.0062	NA	-0.1339	-0.0053	-0.0059	-0.0054	-0.0060
924	QT 11-12	0.3513	0.3379	0.2839	0.3524	0.3439	0.3446	0.3399
925	QT 2-12	0.1942	NA	0.2096	0.2099	0.2062	0.2070	0.2027
926	QT 3-12	0.0886	NA	0.0593	0.0915	0.0906	0.0905	0.0895
927	QT 7-12	0.0576	NA	0.1408	0.0589	0.0599	0.0589	0.0589
928	QT 11-13	-0.1216	-0.1259	-0.1044	-0.1173	-0.1269	-0.1259	-0.1297
929	QT 12-14	-0.0414	NA	-0.0504	-0.0412	-0.0485	-0.0457	-0.0574
930	QT 13-15	-0.0204	-0.0202	0.0129	-0.0122	-0.0231	-0.0202	-0.0248
931	QT 14-15	-0.0783	NA	-0.0196	-0.0667	-0.0803	-0.0775	-0.0800
932	QT 12-16	-0.0632	NA	-0.0340	-0.0572	-0.0709	-0.0695	-0.0725
933	QT 15-17	0.2522	0.2547	0.2838	0.2478	0.2445	0.2441	0.2431
934	QT 16-17	-0.0030	NA	0.0445	0.0065	-0.0064	-0.0026	-0.0090
935	QT 17-18	-0.2240	NA	-0.2183	-0.2164	-0.2173	-0.2163	-0.2164
936	QT 18-19	-0.1755	-0.1723	-0.1856	-0.1723	-0.1767	-0.1723	-0.1764
937	QT 19-20	-0.0771	NA	-0.0647	-0.0717	-0.0732	-0.0641	-0.0740
938	QT 15-19	-0.1650	NA	-0.1340	-0.1563	-0.1658	-0.1602	-0.1663
939	QT 20-21	-0.0590	-0.0578	-0.0535	-0.0535	-0.0568	-0.0505	-0.0578
940	QT 21-22	0.0176	0.0179	0.0177	0.0179	0.0183	0.0179	0.0182
941	QT 22-23	0.0769	0.0749	0.0768	0.0696	0.0739	0.0749	0.0749
942	QT 23-24	-0.1524	NA	-0.1599	-0.1545	-0.1532	-0.1536	-0.1542
943	QT 23-25	0.3863	0.3793	0.3932	0.4135	0.4030	0.3922	0.3986
944	QT 26-25	-0.1864	-0.1919	-0.1859	-0.1919	-0.1909	-0.1782	-0.1919
945	QT 25-27	-0.1525	NA	-0.1560	-0.1427	-0.1660	-0.1516	-0.1548
946	QT 27-28	-0.0043	-0.0044	-0.0087	-0.0193	-0.0054	-0.0095	-0.0044
947	QT 28-29	0.0464	NA	0.0461	0.0445	0.0456	0.0445	0.0446
948	QT 30-17	-0.7010	NA	-0.7018	-0.7291	-0.7344	-0.7320	-0.7297
949	QT 8-30	-0.7542	-0.7834	-0.7033	-0.7405	-0.7630	-0.7526	-0.7716
950	QT 26-30	-0.3657	NA	-0.3903	-0.3860	-0.3792	-0.3842	-0.3708
951	QT 17-31	-0.1473	NA	-0.1387	-0.1328	-0.1455	-0.1334	-0.1442
952	QT 29-31	0.0792	0.0803	0.0786	0.0803	0.0813	0.0747	0.0803
953	QT 23-32	-0.0624	NA	-0.0647	-0.0364	-0.0728	-0.0626	-0.0635
954	QT 31-32	-0.1360	NA	-0.1308	-0.1230	-0.1344	-0.1291	-0.1353
955	QT 27-32	-0.0343	NA	-0.0326	-0.0351	-0.0333	-0.0350	-0.0351
956	QT 15-33	0.0149	NA	0.0365	0.0363	0.0230	0.0249	0.0212
957	QT 19-34	0.0460	0.0452	0.0587	0.0678	0.0537	0.0559	0.0537

958	QT 35-36	-0.0429	NA	-0.0415	-0.0400	-0.0418	-0.0398	-0.0418
959	QT 35-37	0.1243	0.1219	0.1223	0.1219	0.1229	0.1219	0.1219
960	QT 33-37	0.0746	0.0768	0.0852	0.0944	0.0798	0.0829	0.0811
961	QT 34-36	-0.0498	NA	-0.0528	-0.0559	-0.0526	-0.0535	-0.0516
962	QT 34-37	0.4429	NA	0.4233	0.4119	0.4277	0.4184	0.4261
963	QT 38-37	-0.8801	NA	-0.8450	-0.8032	-0.8749	-0.8604	-0.8679
964	QT 37-39	-0.0230	NA	-0.0386	-0.0429	-0.0239	-0.0235	-0.0238
965	QT 37-40	0.0296	NA	0.0206	0.0176	0.0298	0.0301	0.0298
966	QT 30-38	-0.5598	-0.5403	-0.5471	-0.5392	-0.5549	-0.5486	-0.5549
967	QT 39-40	0.0775	NA	0.0804	0.0803	0.0794	0.0804	0.0804
968	QT 40-41	-0.0221	NA	-0.0245	-0.0219	-0.0228	-0.0218	-0.0219
969	QT 40-42	0.0230	0.0221	0.0183	0.0131	0.0220	0.0201	0.0208
970	QT 41-42	0.0524	0.0527	0.0469	0.0388	0.0513	0.0484	0.0493
971	QT 43-44	-0.0379	NA	-0.0452	-0.0364	-0.0389	-0.0404	-0.0396
972	QT 34-43	-0.0567	NA	-0.0689	-0.1494	-0.0585	-0.0665	-0.0574
973	QT 44-45	-0.0662	NA	-0.0663	0.0746	-0.0690	-0.0612	-0.0704
974	QT 45-46	0.0212	NA	0.0214	-0.0003	0.0184	0.0217	0.0163
975	QT 46-47	-0.0079	-0.0080	-0.0083	-0.0176	-0.0090	-0.0083	-0.0091
976	QT 46-48	0.0142	NA	0.0141	0.0041	0.0123	0.0142	0.0119
977	QT 47-49	0.0928	NA	0.0893	0.0819	0.0884	0.0895	0.0886
978	QT 42-49	0.0037	0.0037	-0.0014	-0.0088	-0.0008	-0.0009	-0.0011
979	QT 42-49	0.0037	0.0038	-0.0014	-0.0088	-0.0008	-0.0009	-0.0011
980	QT 45-49	0.0231	NA	0.0220	-0.0023	0.0191	0.0223	0.0174
981	QT 48-49	-0.0393	-0.0388	-0.0438	-0.0388	-0.0398	-0.0443	-0.0388
982	QT 49-50	-0.1314	-0.1303	-0.1305	-0.1303	-0.1293	-0.1303	-0.1303
983	QT 49-51	-0.1740	-0.1775	-0.1681	-0.1775	-0.1703	-0.1676	-0.1710
984	QT 51-52	-0.0699	-0.0721	-0.0744	-0.0747	-0.0697	-0.0721	-0.0704
985	QT 52-53	-0.0545	NA	-0.0590	-0.0602	-0.0546	-0.0580	-0.0543
986	QT 53-54	0.0299	NA	0.0300	0.0387	0.0291	0.0279	0.0297
987	QT 49-54	-0.1560	-0.1577	-0.1571	-0.1586	-0.1551	-0.1566	-0.1549
988	QT 49-54	-0.1379	NA	-0.1389	-0.1403	-0.1369	-0.1384	-0.1368
989	QT 54-55	-0.0325	NA	-0.0327	-0.0325	-0.0326	-0.0329	-0.0326
990	QT 54-56	-0.0498	-0.0496	-0.0532	-0.0496	-0.0506	-0.0530	-0.0496
991	QT 55-56	0.0557	0.0538	0.0540	0.0555	0.0552	0.0549	0.0555
992	QT 56-57	0.0749	NA	0.0742	0.0452	0.0785	0.0741	0.0774
993	QT 50-57	-0.1049	NA	-0.1084	-0.1327	-0.1011	-0.1074	-0.1009
994	QT 56-58	0.0153	0.0153	0.0227	0.0181	0.0163	0.0227	0.0161
995	QT 51-58	-0.0453	NA	-0.0504	-0.0449	-0.0461	-0.0494	-0.0451
996	QT 54-59	0.0426	0.0432	0.0445	0.0432	0.0420	0.0432	0.0412
997	QT 56-59	0.0099	NA	0.0118	0.0107	0.0095	0.0106	0.0085
998	QT 56-59	0.0113	0.0113	0.0133	0.0122	0.0109	0.0120	0.0099

999	QT 55-59	0.0588	NA	0.0610	0.0595	0.0583	0.0596	0.0574
1000	QT 59-60	-0.0440	NA	-0.0452	-0.0447	-0.0434	-0.0444	-0.0431
1001	QT 59-61	-0.0463	-0.0476	-0.0470	-0.0468	-0.0456	-0.0464	-0.0450
1002	QT 60-61	-0.0823	-0.0831	-0.0785	-0.0831	-0.0821	-0.0793	-0.0779
1003	QT 60-62	0.0574	NA	0.0527	0.0461	0.0510	0.0505	0.0544
1004	QT 61-62	0.1320	NA	0.1236	0.1155	0.1224	0.1205	0.1259
1005	QT 63-59	-0.5702	-0.5856	-0.5690	-0.5664	-0.5728	-0.5704	-0.5746
1006	QT 63-64	0.5251	0.5083	0.5251	0.5263	0.5277	0.5267	0.5293
1007	QT 64-61	-0.1368	NA	-0.1402	-0.1409	-0.1375	-0.1402	-0.1378
1008	QT 38-65	-0.0837	NA	-0.1045	-0.1311	-0.1003	-0.0939	-0.0914
1009	QT 64-65	0.4006	NA	0.4068	0.4126	0.4080	0.4084	0.4078
1010	QT 49-66	0.0832	0.0853	0.0839	0.0743	0.0843	0.0832	0.0853
1011	QT 49-66	0.0832	NA	0.0839	0.0743	0.0843	0.0832	0.0853
1012	QT 62-66	0.1468	0.1514	0.1492	0.1514	0.1490	0.1500	0.1481
1013	QT 62-67	0.1215	NA	0.1266	0.1273	0.1263	0.1258	0.1252
1014	QT 65-66	-0.7055	-0.6965	-0.7052	-0.6979	-0.7101	-0.7047	-0.7124
1015	QT 66-67	-0.1915	-0.1917	-0.1891	-0.1917	-0.1876	-0.1917	-0.1883
1016	QT 65-68	-0.4185	NA	-0.4049	-0.3482	-0.4180	-0.4046	-0.4190
1017	QT 47-69	-0.1007	NA	-0.0976	-0.0983	-0.0992	-0.0978	-0.0981
1018	QT 49-69	-0.1206	-0.1240	-0.1174	-0.1165	-0.1185	-0.1176	-0.1177
1019	QT 68-69	-1.0364	-1.0038	-1.0155	-1.0038	-1.0260	-1.0153	-1.0219
1020	QT 69-70	-0.1398	NA	-0.1381	-0.1327	-0.1438	-0.1380	-0.1454
1021	QT 24-70	-0.0680	-0.0701	-0.0716	-0.0692	-0.0669	-0.0684	-0.0676
1022	QT 70-71	0.1168	NA	0.1324	0.1499	0.1191	0.1279	0.1168
1023	QT 24-72	-0.0798	-0.0776	-0.0798	-0.0776	-0.0775	-0.0776	-0.0790
1024	QT 71-72	-0.0315	NA	-0.0245	-0.0315	-0.0304	-0.0282	-0.0313
1025	QT 71-73	0.0965	NA	0.1051	0.1300	0.0969	0.1045	0.0959
1026	QT 70-74	-0.1542	-0.1599	-0.1635	-0.1665	-0.1565	-0.1599	-0.1559
1027	QT 70-75	-0.1317	NA	-0.1416	-0.1437	-0.1340	-0.1375	-0.1337
1028	QT 69-75	-0.1831	NA	-0.1925	-0.1896	-0.1893	-0.1877	-0.1906
1029	QT 74-75	0.0644	NA	0.0603	0.0627	0.0637	0.0626	0.0626
1030	QT 76-77	0.2439	NA	0.2540	0.2634	0.2521	0.2521	0.2534
1031	QT 69-77	-0.1380	-0.1372	-0.1381	-0.1240	-0.1382	-0.1372	-0.1381
1032	QT 75-77	0.0738	0.0760	0.0802	0.0857	0.0780	0.0775	0.0787
1033	QT 77-78	-0.0763	NA	-0.0405	-0.0262	-0.0489	-0.0465	-0.0521
1034	QT 78-79	0.1795	NA	0.1766	0.1782	0.1772	0.1757	0.1782
1035	QT 77-80	0.3753	NA	0.3693	0.3788	0.3697	0.3674	0.3721
1036	QT 77-80	0.2059	NA	0.2033	0.2079	0.2035	0.2024	0.2046
1037	QT 79-80	0.3108	0.2989	0.3020	0.3055	0.3035	0.3020	0.3055
1038	QT 68-81	-0.7554	NA	-0.7427	-0.7010	-0.7502	-0.7425	-0.7551
1039	QT 81-80	-0.7305	NA	-0.7182	-0.6786	-0.7245	-0.7180	-0.7138

1040	QT 77-82	-0.2528	NA	-0.2579	-0.2574	-0.2540	-0.2536	-0.2533
1041	QT 82-83	-0.2699	-0.2697	-0.2770	-0.2717	-0.2707	-0.2750	-0.2697
1042	QT 83-84	-0.1599	NA	-0.1671	-0.1621	-0.1628	-0.1622	-0.1614
1043	QT 83-85	-0.1229	NA	-0.1289	-0.1249	-0.1242	-0.1249	-0.1239
1044	QT 84-85	-0.0924	NA	-0.0906	-0.0927	-0.0909	-0.0921	-0.0923
1045	QT 85-86	0.0509	0.0497	0.0507	0.0497	0.0507	0.0497	0.0497
1046	QT 86-87	0.1102	0.1112	0.1118	0.1112	0.1122	0.1112	0.1112
1047	QT 85-88	-0.0753	NA	-0.0761	-0.0736	-0.0733	-0.0729	-0.0737
1048	QT 85-89	0.0373	NA	0.0381	0.0372	0.0382	0.0380	0.0375
1049	QT 88-89	0.0770	0.0756	0.0804	0.0756	0.0754	0.0756	0.0756
1050	QT 89-90	0.0581	NA	0.0598	0.0591	0.0586	0.0587	0.0581
1051	QT 89-90	0.0707	0.0725	0.0736	0.0725	0.0713	0.0716	0.0704
1052	QT 90-91	-0.0646	NA	-0.0598	-0.0640	-0.0667	-0.0652	-0.0671
1053	QT 89-92	0.1696	NA	0.1731	0.1639	0.1696	0.1702	0.1673
1054	QT 89-92	0.0729	NA	0.0740	0.0710	0.0730	0.0730	0.0721
1055	QT 91-92	0.0359	NA	0.0319	0.0319	0.0368	0.0359	0.0368
1056	QT 92-93	0.1250	NA	0.1172	0.1223	0.1213	0.1222	0.1222
1057	QT 92-94	0.1591	0.1633	0.1667	0.1633	0.1620	0.1601	0.1600
1058	QT 93-94	0.1944	NA	0.2193	0.2065	0.2043	0.1996	0.1995
1059	QT 94-95	-0.0931	NA	-0.0979	-0.0962	-0.0973	-0.0962	-0.0963
1060	QT 80-96	-0.2462	NA	-0.2465	-0.2485	-0.2454	-0.2454	-0.2460
1061	QT 82-96	0.0129	NA	0.0152	0.0163	0.0129	0.0101	0.0119
1062	QT 94-96	0.0798	0.0799	0.0778	0.0794	0.0782	0.0794	0.0791
1063	QT 80-97	-0.2719	NA	-0.2723	-0.2758	-0.2720	-0.2725	-0.2732
1064	QT 80-98	-0.1043	-0.1038	-0.1057	-0.1030	-0.1063	-0.1055	-0.1078
1065	QT 80-99	-0.1294	NA	-0.1288	-0.1248	-0.1289	-0.1277	-0.1295
1066	QT 92-100	0.1537	NA	0.1570	0.1604	0.1528	0.1533	0.1517
1067	QT 94-100	0.4581	0.4462	0.4535	0.4787	0.4472	0.4536	0.4462
1068	QT 95-96	0.2051	NA	0.2059	0.2070	0.2059	0.2070	0.2067
1069	QT 96-97	0.1819	0.1884	0.1820	0.1827	0.1799	0.1794	0.1800
1070	QT 98-100	-0.0730	NA	-0.0729	-0.0695	-0.0736	-0.0727	-0.0741
1071	QT 99-100	0.0279	NA	0.0245	0.0255	0.0225	0.0227	0.0209
1072	QT 100-101	-0.2513	NA	-0.2628	-0.3021	-0.2534	-0.2498	-0.2544
1073	QT 92-102	0.0813	NA	0.0755	0.0524	0.0770	0.0796	0.0755
1074	QT 101-102	-0.1113	NA	-0.1086	-0.0822	-0.1078	-0.1127	-0.1053
1075	QT 100-103	0.2436	0.2370	0.2421	0.2370	0.2380	0.2421	0.2370
1076	QT 100-104	-0.0941	NA	-0.0931	-0.0980	-0.0946	-0.0940	-0.0953

1077	QT 103-104	-0.1583	NA	-0.1566	-0.1610	-0.1571	-0.1577	-0.1577
1078	QT 103-105	-0.1348	NA	-0.1335	-0.1391	-0.1340	-0.1343	-0.1343
1079	QT 100-106	-0.0712	NA	-0.0699	-0.0758	-0.0713	-0.0704	-0.0710
1080	QT 104-105	-0.0261	-0.0260	-0.0264	-0.0332	-0.0270	-0.0260	-0.0260
1081	QT 105-105	-0.0515	-0.0506	-0.0476	-0.0506	-0.0483	-0.0476	-0.0454
1082	QT 105-107	-0.0055	NA	-0.0046	-0.0110	-0.0039	-0.0046	-0.0040
1083	QT 105-108	0.0992	NA	0.0946	0.0952	0.0963	0.0958	0.0952
1084	QT 106-107	0.0055	0.0053	0.0054	-0.0002	0.0063	0.0053	0.0053
1085	QT 108-109	0.1039	0.1055	0.1059	0.1055	0.1065	0.1081	0.1081
1086	QT 103-110	-0.0615	NA	-0.0619	-0.0718	-0.0596	-0.0614	-0.0593
1087	QT 109-110	0.1177	NA	0.1173	0.1063	0.1221	0.1183	0.1237
1088	QT 110-111	-0.0184	NA	-0.0208	-0.0480	-0.0196	-0.0186	-0.0186
1089	QT 110-112	0.2851	NA	0.2730	0.2812	0.2802	0.2735	0.2812
1090	QT 17-113	-0.0665	NA	-0.0671	-0.0641	-0.0631	-0.0641	-0.0641
1091	QT 32-113	0.1340	0.1336	0.1240	0.1157	0.1322	0.1195	0.1314
1092	QT 32-114	-0.0322	-0.0322	-0.0327	-0.0322	-0.0332	-0.0322	-0.0322
1093	QT 27-115	-0.0653	NA	-0.0642	-0.0663	-0.0652	-0.0662	-0.0662
1094	QT 114-115	-0.0047	NA	-0.0050	-0.0047	-0.0057	-0.0047	-0.0047
1095	QT 68-116	0.5132	0.4934	0.4895	0.4934	0.4944	0.4895	0.4934
1096	QT 12-117	-0.0800	#N/A	-0.0939	-0.0808	-0.0810	-0.0809	-0.0812
1097	QT 75-118	-0.2356	#N/A	-0.2395	-0.2415	-0.2407	-0.2417	-0.2417
1098	QT 76-118	0.0856	#N/A	0.0853	0.0877	0.0871	0.0882	0.0873

B.3.3 Presence of a Multiple Non-interacting Bad-data

Table B.12 IEEE 118 Bus System with five multiple non-interacting bad-data in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				

				WLS	WLAV	LMR	HLMR	ULMR
1	Vm-1	0.9550	NA	0.9712	0.9526	0.9569	0.9541	0.9570
2	Vm-2	0.9714	0.9687	0.9820	0.9687	0.9731	0.9701	0.9731
3	Vm-3	0.9677	1.0494	0.9804	0.9654	0.9699	0.9670	0.9698
4	Vm-4	0.9980	0.9888	1.0014	0.9960	1.0004	0.9977	1.0004
5	Vm-5	1.0020	0.9945	1.0052	1.0000	1.0044	1.0017	1.0044
6	Vm-6	0.9900	NA	0.9987	0.9878	0.9924	0.9896	0.9922
7	Vm-7	0.9893	NA	0.9986	0.9871	0.9917	0.9889	0.9915
8	Vm-8	1.0150	NA	1.0210	1.0159	1.0173	1.0154	1.0171
9	Vm-9	1.0429	1.0463	1.0498	1.0463	1.0454	1.0437	1.0451
10	Vm-10	1.0500	NA	1.0573	1.0556	1.0522	1.0509	1.0520
11	Vm-11	0.9851	NA	0.9959	0.9832	0.9874	0.9849	0.9876
12	Vm-12	0.9900	0.9828	1.0002	0.9879	0.9931	0.9897	0.9923
13	Vm-13	0.9683	NA	0.9901	0.9703	0.9703	0.9680	0.9707
14	Vm-14	0.9836	NA	0.9918	0.9786	0.9850	0.9827	0.9847
15	Vm-15	0.9700	0.9703	0.9798	0.9713	0.9711	0.9698	0.9709
16	Vm-16	0.9839	NA	0.9937	0.9827	0.9933	0.9832	0.9854
17	Vm-17	0.9951	1.0000	1.0043	0.9966	0.9959	0.9946	0.9955
18	Vm-18	0.9730	0.9768	0.9821	0.9749	0.9741	0.9728	0.9738
19	Vm-19	0.9620	NA	0.9712	0.9638	0.9630	0.9620	0.9628
20	Vm-20	0.9569	NA	0.9668	0.9593	0.9584	0.9585	0.9582
21	Vm-21	0.9577	0.9604	0.9679	0.9604	0.9595	0.9601	0.9591
22	Vm-22	0.9690	NA	0.9799	0.9719	0.9709	0.9714	0.9706
23	Vm-23	0.9995	1.0001	1.0140	1.0038	1.0010	1.0014	1.0006
24	Vm-24	0.9920	1.0673	1.0067	0.9963	0.9935	0.9939	0.9930
25	Vm-25	1.0500	1.0536	1.0638	1.0539	1.0526	1.0524	1.0521
26	Vm-26	1.0150	NA	1.0283	1.0178	1.0176	1.0170	1.0172
27	Vm-27	0.9680	0.9732	0.9772	0.9725	0.9694	0.9700	0.9690
28	Vm-28	0.9616	0.9598	0.9700	0.9651	0.9628	0.9630	0.9625
29	Vm-29	0.9632	0.9696	0.9722	0.9666	0.9642	0.9646	0.9640
30	Vm-30	0.9853	1.0691	0.9941	0.9872	0.9870	0.9859	0.9868
31	Vm-31	0.9670	NA	0.9763	0.9703	0.9681	0.9683	0.9678
32	Vm-32	0.9630	NA	0.9737	0.9674	0.9645	0.9651	0.9639
33	Vm-33	0.9709	NA	0.9802	0.9744	0.9729	0.9719	0.9725
34	Vm-34	0.9840	0.9922	0.9928	0.9903	0.9866	0.9864	0.9865
35	Vm-35	0.9805	NA	0.9895	0.9866	0.9831	0.9828	0.9830
36	Vm-36	0.9800	0.9866	0.9889	0.9862	0.9826	0.9823	0.9825
37	Vm-37	0.9907	0.9967	0.9999	0.9967	0.9932	0.9928	0.9930
38	Vm-38	0.9613	NA	0.9685	0.9642	0.9633	0.9625	0.9630
39	Vm-39	0.9700	NA	0.9740	0.9745	0.9728	0.9723	0.9726
40	Vm-40	0.9700	0.9747	0.9742	0.9747	0.9729	0.9725	0.9728
41	Vm-41	0.9668	NA	0.9707	0.9715	0.9697	0.9693	0.9696

42	Vm-42	0.9850	0.9796	0.9867	0.9876	0.9873	0.9867	0.9872
43	Vm-43	0.9771	NA	0.9827	0.9678	0.9796	0.9779	0.9796
44	Vm-44	0.9844	0.9748	0.9838	0.9754	0.9867	0.9844	0.9866
45	Vm-45	0.9864	0.9905	0.9836	0.9896	0.9884	0.9867	0.9881
46	Vm-46	1.0050	1.0054	1.0021	1.0054	1.0064	1.0053	1.0060
47	Vm-47	1.0171	NA	1.0147	1.0162	1.0182	1.0173	1.0179
48	Vm-48	1.0206	NA	1.0172	1.0191	1.0216	1.0209	1.0213
49	Vm-49	1.0250	1.0334	1.0224	1.0235	1.0260	1.0251	1.0257
50	Vm-50	1.0011	NA	0.9890	0.9999	1.0025	1.0015	1.0020
51	Vm-51	0.9669	0.9762	0.9698	0.9643	0.9680	0.9674	0.9678
52	Vm-52	0.9568	NA	0.9598	0.9538	0.9579	0.9572	0.9576
53	Vm-53	0.9460	0.9407	0.9490	0.9419	0.9471	0.9457	0.9468
54	Vm-54	0.9550	0.9515	0.9587	0.9521	0.9561	0.9546	0.9559
55	Vm-55	0.9520	NA	0.9559	0.9490	0.9530	0.9515	0.9528
56	Vm-56	0.9540	0.9511	0.9579	0.9511	0.9550	0.9535	0.9549
57	Vm-57	0.9706	0.9646	0.9778	0.9646	0.9719	0.9700	0.9716
58	Vm-58	0.9590	NA	0.9624	0.9564	0.9601	0.9593	0.9599
59	Vm-59	0.9850	0.9915	0.9885	0.9821	0.9860	0.9847	0.9856
60	Vm-60	0.9932	NA	0.9950	0.9903	0.9943	0.9928	0.9939
61	Vm-61	0.9950	NA	0.9969	0.9921	0.9961	0.9947	0.9958
62	Vm-62	0.9980	0.9923	0.9991	0.9945	0.9986	0.9972	0.9984
63	Vm-63	0.9687	0.9648	0.9712	0.9660	0.9698	0.9685	0.9694
64	Vm-64	0.9837	0.9782	0.9856	0.9810	0.9848	0.9835	0.9845
65	Vm-65	1.0050	NA	1.0059	1.0027	1.0063	1.0050	1.0060
66	Vm-66	1.0500	NA	1.0498	1.0478	1.0511	1.0501	1.0509
67	Vm-67	1.0197	NA	1.0203	1.0168	1.0205	1.0194	1.0204
68	Vm-68	1.0032	0.9981	1.0043	1.0021	1.0045	1.0035	1.0043
69	Vm-69	1.0350	1.0435	1.0366	1.0350	1.0368	1.0361	1.0367
70	Vm-70	0.9840	0.9887	0.9886	0.9861	0.9856	0.9854	0.9852
71	Vm-71	0.9868	0.9886	0.9932	0.9909	0.9885	0.9886	0.9881
72	Vm-72	0.9800	NA	0.9939	0.9849	0.9818	0.9824	0.9812
73	Vm-73	0.9910	0.9973	0.9977	0.9973	0.9927	0.9932	0.9922
74	Vm-74	0.9580	NA	0.9594	0.9572	0.9592	0.9586	0.9590
75	Vm-75	0.9673	0.9578	0.9683	0.9664	0.9684	0.9678	0.9681
76	Vm-76	0.9430	0.9415	0.9437	0.9415	0.9438	0.9431	0.9435
77	Vm-77	1.0060	1.0122	1.0079	1.0078	1.0080	1.0073	1.0079
78	Vm-78	1.0034	NA	1.0057	1.0059	1.0057	1.0051	1.0055
79	Vm-79	1.0092	NA	1.0114	1.0117	1.0115	1.0108	1.0113
80	Vm-80	1.0400	1.0495	1.0417	1.0421	1.0418	1.0410	1.0418
81	Vm-81	0.9968	NA	0.9981	0.9969	0.9982	0.9973	0.9979
82	Vm-82	0.9885	0.9897	0.9899	0.9897	0.9905	0.9899	0.9904
83	Vm-83	0.9844	NA	0.9855	0.9856	0.9864	0.9856	0.9863

84	Vm-84	0.9797	NA	0.9797	0.9812	0.9815	0.9807	0.9818
85	Vm-85	0.9850	0.9763	0.9851	0.9861	0.9870	0.9860	0.9869
86	Vm-86	0.9867	0.9875	0.9867	0.9875	0.9886	0.9875	0.9884
87	Vm-87	1.0150	NA	1.0153	1.0160	1.0172	1.0160	1.0169
88	Vm-88	0.9875	NA	0.9873	0.9886	0.9896	0.9886	0.9895
89	Vm-89	1.0050	NA	1.0052	1.0060	1.0071	1.0061	1.0069
90	Vm-90	0.9850	NA	0.9853	0.9862	0.9871	0.9860	0.9868
91	Vm-91	0.9800	0.9868	0.9808	0.9815	0.9820	0.9810	0.9818
92	Vm-92	0.9900	0.9806	0.9904	0.9909	0.9921	0.9911	0.9919
93	Vm-93	0.9854	NA	0.9852	0.9862	0.9873	0.9865	0.9872
94	Vm-94	0.9898	0.9921	0.9914	0.9913	0.9919	0.9911	0.9917
95	Vm-95	0.9803	NA	0.9817	0.9817	0.9822	0.9814	0.9821
96	Vm-96	0.9923	NA	0.9938	0.9938	0.9943	0.9935	0.9941
97	Vm-97	1.0112	NA	1.0127	1.0129	1.0130	1.0122	1.0128
98	Vm-98	1.0235	NA	1.0250	1.0256	1.0250	1.0244	1.0249
99	Vm-99	1.0100	NA	1.0116	1.0129	1.0118	1.0113	1.0117
100	Vm-100	1.0170	1.0221	1.0182	1.0196	1.0184	1.0179	1.0182
101	Vm-101	0.9914	0.9859	0.9912	0.9874	0.9927	0.9922	0.9923
102	Vm-102	0.9891	0.9915	0.9892	0.9884	0.9909	0.9901	0.9907
103	Vm-103	1.0100	1.0141	1.0112	1.0124	1.0112	1.0110	1.0109
104	Vm-104	0.9710	NA	0.9728	0.9732	0.9727	0.9723	0.9722
105	Vm-105	0.9650	0.9742	0.9668	0.9669	0.9667	0.9663	0.9662
106	Vm-106	0.9611	NA	0.9632	0.9631	0.9630	0.9627	0.9628
107	Vm-107	0.9520	0.9527	0.9539	0.9527	0.9540	0.9534	0.9535
108	Vm-108	0.9662	NA	0.9676	0.9678	0.9676	0.9672	0.9672
109	Vm-109	0.9670	NA	0.9685	0.9687	0.9685	0.9682	0.9681
110	Vm-110	0.9730	0.9825	0.9743	0.9736	0.9748	0.9741	0.9745
111	Vm-111	0.9800	0.9782	0.9811	0.9782	0.9816	0.9810	0.9814
112	Vm-112	0.9750	0.9667	0.9758	0.9756	0.9767	0.9757	0.9765
113	Vm-113	0.9930	0.9858	1.0021	0.9946	0.9939	0.9926	0.9935
114	Vm-114	0.9601	0.9645	0.9700	0.9645	0.9615	0.9622	0.9610
115	Vm-115	0.9600	NA	0.9699	0.9645	0.9614	0.9621	0.9609
116	Vm-116	1.0050	NA	1.0059	1.0038	1.0062	1.0051	1.0059
117	Vm-117	0.9738	NA	0.9839	0.9716	0.9768	0.9734	0.9760
118	Vm-118	0.9494	NA	0.9502	0.9481	0.9503	0.9496	0.9500
119	PG-1	-0.5100	NA	-0.4774	-0.5171	-0.5243	-0.5173	-0.5188
120	PG-2	-0.2000	NA	-0.1551	-0.2052	-0.2364	-0.2052	-0.2052
121	PG-3	-0.3900	-0.3849	-0.4036	-0.3849	-0.3859	-0.3849	-0.3834
122	PG-4	-0.3900	-0.3958	-0.4929	-0.3958	-0.3968	-0.3958	-0.3973
123	PG-5	0.0000	NA	-1.0806	0.0097	0.0184	-0.0003	-0.0085
124	PG-6	-0.5200	NA	-0.3442	-0.5065	-0.5066	-0.5064	-0.5092
125	PG-7	-0.1900	NA	-0.2339	-0.1991	-0.2635	-0.1968	-0.1991

126	PG-8	-0.2800	-0.2824	-0.2639	-0.2824	-0.2814	-0.2824	-0.2824
127	PG-9	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	0.0002
128	PG-10	4.5000	NA	4.5000	4.4834	4.4826	4.4838	4.4837
129	PG-11	-0.7000	NA	0.1873	-0.6886	-0.8766	-0.6928	-0.6913
130	PG-12	0.3800	0.3848	0.4182	0.3848	0.3838	0.3848	0.3844
131	PG-13	-0.3400	-0.3381	-0.3244	-0.3381	-0.3372	-0.3381	-0.3381
132	PG-14	-0.1400	NA	-0.0745	-0.1438	-0.1907	-0.1429	-0.1418
133	PG-15	-0.9000	-0.8950	-0.9089	-0.8950	-0.8960	-0.8950	-0.8950
134	PG-16	-0.2500	-0.2480	-0.2251	-0.2480	0.2470	-0.2480	-0.2480
135	PG-17	-0.1100	NA	-0.1257	-0.0834	-0.2752	-0.0660	-0.0925
136	PG-18	-0.6000	NA	-0.6115	-0.6005	-0.6047	-0.6016	-0.6058
137	PG-19	-0.4500	-0.4509	-0.4618	-0.4509	-0.4519	-0.4509	-0.4509
138	PG-20	-0.1800	-0.1776	-0.1847	-0.1776	-0.1786	-0.1807	-0.1776
139	PG-21	-0.1400	NA	-0.1428	-0.1446	-0.1446	-0.1412	-0.1449
140	PG-22	-0.1000	NA	-0.0947	-0.0831	-0.0851	-0.0918	-0.0847
141	PG-23	-0.0700	NA	-0.1053	-0.0996	-0.0987	-0.1104	-0.1034
142	PG-24	-0.1300	-0.1323	-0.1353	-0.1323	-0.1313	-0.1323	-0.1308
143	PG-25	2.2000	2.2435	2.2395	2.2435	2.2441	2.2467	2.2435
144	PG-26	3.1400	NA	3.1384	3.1549	3.1597	3.1228	3.1612
145	PG-27	-0.7100	NA	-0.7121	-0.7157	-0.7173	-0.7106	-0.7167
146	PG-28	-0.1700	NA	-0.1749	-0.1738	-0.1752	-0.1768	-0.1738
147	PG-29	-0.2400	NA	-0.2372	-0.2357	-0.2382	-0.2369	-0.2381
148	PG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
149	PG-31	-0.3600	-0.3664	-0.3655	-0.3664	-0.3654	-0.3664	-0.3649
150	PG-32	-0.5900	NA	-0.5995	-0.5987	-0.5941	-0.6035	-0.5949
151	PG-33	-0.2300	-0.2314	-0.2453	-0.2379	-0.2324	-0.2314	-0.2314
152	PG-34	-0.5900	NA	-0.6251	-0.6034	-0.6129	-0.5978	-0.5982
153	PG-35	-0.3300	-0.3295	-0.3303	-0.3295	-0.3305	-0.3295	-0.3295
154	PG-36	-0.3100	-0.3044	-0.3051	-0.3044	-0.3054	-0.3044	-0.3044
155	PG-37	0.0000	NA	-0.0470	-0.0808	-0.0198	-0.0226	-0.0344
156	PG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	-0.0002
157	PG-39	-0.2700	NA	-0.2758	-0.2549	-0.2559	-0.2632	-0.2604
158	PG-40	-0.6600	NA	-0.6597	-0.6476	-0.6483	-0.6520	-0.6507
159	PG-41	-0.3700	NA	-0.3713	-0.3676	-0.3687	-0.3676	-0.3683
160	PG-42	-0.9600	-0.9690	-0.9722	-0.9690	-0.9680	-0.9690	-0.9690
161	PG-43	-0.1800	NA	-0.1781	-0.1788	-0.1794	-0.1805	-0.1807
162	PG-44	-0.1600	-0.1581	-0.1580	-0.1581	-0.1591	-0.1581	-0.1581
163	PG-45	-0.5300	NA	-0.5479	-0.5331	-0.5298	-0.5253	-0.5323
164	PG-46	-0.0900	-0.0884	-0.0910	-0.0884	-0.0894	-0.0907	-0.0899
165	PG-47	-0.3400	-0.3455	-0.3529	-0.3455	-0.3445	-0.3455	-0.3440
166	PG-48	-0.2000	NA	-0.2150	-0.2004	-0.2015	-0.2009	-0.1998
167	PG-49	1.1700	1.1639	1.1490	1.1639	1.1629	1.1639	1.1624

168	PG-50	-0.1700	NA	-0.7594	-0.1473	-0.1512	-0.1503	-0.1536
169	PG-51	-0.1700	NA	-0.1441	-0.1740	-0.1746	-0.1733	-0.1703
170	PG-52	-0.1800	-0.1806	-0.1843	-0.1826	-0.1816	-0.1833	-0.1822
171	PG-53	-0.2300	-0.2321	-0.2066	-0.2321	-0.2331	-0.2321	-0.2336
172	PG-54	-0.6500	-0.6479	-0.5821	-0.6479	-0.6489	-0.6486	-0.6492
173	PG-55	-0.6300	-0.6404	-0.6078	-0.6404	-0.6394	-0.6404	-0.6389
174	PG-56	-0.8400	NA	-0.8247	-0.8204	-0.8336	-0.8289	-0.8326
175	PG-57	-0.1200	NA	0.5142	-0.1377	-0.1342	-0.1324	-0.1339
176	PG-58	-0.1200	NA	-0.1322	-0.1215	-0.1215	-0.1224	-0.1219
177	PG-59	-1.2200	NA	-1.3848	-1.2571	-1.2174	-1.2301	-1.2119
178	PG-60	-0.7800	NA	-0.7635	-0.7772	-0.7403	-0.7588	-0.7434
179	PG-61	1.6000	1.5911	1.5831	1.5911	1.5901	1.5827	1.5896
180	PG-62	-0.7700	NA	-0.7922	-0.7712	-0.8038	-0.7962	-0.7971
181	PG-63	0.0000	NA	0.0000	0.0000	-0.0181	0.0000	-0.0216
182	PG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
183	PG-65	3.9100	NA	3.9947	3.9713	3.9436	3.9370	3.9396
184	PG-66	3.5300	3.5670	3.5632	3.5670	3.5660	3.5603	3.5655
185	PG-67	-0.2800	NA	-0.2839	-0.3031	-0.3012	-0.2857	-0.3013
186	PG-68	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
187	PG-69	5.1386	NA	5.1570	5.1265	5.1210	5.1278	5.1226
188	PG-70	-0.6600	-0.6498	-0.6515	-0.6498	-0.6508	-0.6498	-0.6513
189	PG-71	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
190	PG-72	-0.1200	NA	-0.1272	-0.1231	-0.1214	-0.1248	-0.1210
191	PG-73	-0.0600	NA	-0.0620	-0.0590	-0.0601	-0.0591	-0.0591
192	PG-74	-0.6800	NA	-0.6723	-0.6758	-0.6735	-0.6735	-0.6751
193	PG-75	-0.4700	NA	-0.4864	-0.4847	-0.4845	-0.4845	-0.4853
194	PG-76	-0.6800	NA	-0.6817	-0.6853	-0.6798	-0.6817	-0.6791
195	PG-77	-0.6100	-0.6014	-0.6013	-0.6014	-0.6004	-0.6014	-0.5999
196	PG-78	-0.7100	NA	-0.7260	-0.7180	-0.7256	-0.7248	-0.7271
197	PG-79	-0.3900	-0.3952	-0.3962	-0.3952	-0.3962	-0.3952	-0.3951
198	PG-80	3.4700	NA	3.5059	3.5026	3.4956	3.5007	3.4988
199	PG-81	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
200	PG-82	-0.5400	NA	-0.5430	-0.5485	-0.5467	-0.5435	-0.5491
201	PG-83	-0.2000	-0.2017	-0.1981	-0.2017	-0.2007	-0.1982	-0.2002
202	PG-84	-0.1100	NA	-0.1092	-0.0889	-0.1112	-0.1087	-0.0994
203	PG-85	-0.2400	-0.2384	-0.2348	-0.2384	-0.2374	-0.2348	-0.2369
204	PG-86	-0.2100	-0.2101	-0.2093	-0.2101	-0.2099	-0.2101	-0.2114
205	PG-87	0.0400	NA	0.0402	0.0398	0.0388	0.0398	0.0398
206	PG-88	-0.4800	NA	-0.4896	-0.4937	-0.4819	-0.4882	-0.4880
207	PG-89	6.0700	NA	6.0798	6.0620	6.0978	6.0760	6.0782
208	PG-90	-1.6300	-1.6414	-1.6429	-1.6414	-1.6424	-1.6414	-1.6429
209	PG-91	-0.1000	NA	-0.0967	-0.0909	-0.0969	-0.0997	-0.0944

210	PG-92	-0.6500	-0.6440	-0.6454	-0.6440	-0.6450	-0.6440	-0.6455
211	PG-93	-0.1200	NA	-0.1138	-0.1105	-0.0989	-0.1096	-0.1059
212	PG-94	-0.3000	NA	-0.3017	-0.3042	-0.3225	-0.3054	-0.3123
213	PG-95	-0.4200	NA	-0.4252	-0.4287	-0.4257	-0.4278	-0.4251
214	PG-96	-0.3800	-0.3754	-0.3770	-0.3754	-0.3764	-0.3754	-0.3769
215	PG-97	-0.1500	-0.1484	-0.1496	-0.1484	-0.1494	-0.1484	-0.1499
216	PG-98	-0.3400	-0.3426	-0.3398	-0.3426	-0.3416	-0.3398	-0.3411
217	PG-99	-0.4200	-0.4243	-0.4214	-0.4243	-0.4233	-0.4243	-0.4243
218	PG-100	2.1500	NA	2.1303	2.1359	2.1301	2.1374	2.1370
219	PG-101	-0.2200	NA	-0.2175	-0.2147	-0.2210	-0.2174	-0.2179
220	PG-102	-0.0500	-0.0491	-0.0506	-0.0491	-0.0501	-0.0491	-0.0506
221	PG-103	0.1700	NA	0.1626	0.1669	0.1671	0.1658	0.1659
222	PG-104	-0.3800	-0.3732	-0.3713	-0.3732	-0.3722	-0.3713	-0.3717
223	PG-105	-0.3100	-0.3093	-0.3087	-0.3093	-0.3095	-0.3093	-0.3093
224	PG-106	-0.4300	NA	-0.4214	-0.4250	-0.4244	-0.4250	-0.4251
225	PG-107	-0.5000	NA	-0.5011	-0.5025	-0.5002	-0.5025	-0.5024
226	PG-108	-0.0200	NA	-0.0225	-0.0224	-0.0227	-0.0224	-0.0224
227	PG-109	-0.0800	NA	-0.0741	-0.0736	-0.0754	-0.0743	-0.0758
228	PG-110	-0.3900	-0.3969	-0.3960	-0.3969	-0.3959	-0.3969	-0.3954
229	PG-111	0.3600	0.3566	0.3572	0.3566	0.3568	0.3566	0.3566
230	PG-112	-0.6800	-0.6720	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
231	PG-113	-0.0600	NA	-0.0558	-0.0594	-0.0596	-0.0512	-0.0581
232	PG-114	-0.0800	NA	-0.0806	-0.0797	-0.0797	-0.0797	-0.0797
233	PG-115	-0.2200	NA	-0.2227	-0.2234	-0.2234	-0.2234	-0.2219
234	PG-116	-1.8400	-1.8683	-1.8440	-1.8291	-1.8321	-1.8444	-1.8310
235	PG-117	-0.2000	-0.1997	-0.1825	-0.1994	-0.1996	-0.1997	-0.1986
236	PG-118	-0.3300	-0.3321	-0.3291	-0.3321	-0.3311	-0.3291	-0.3306
237	QG-1	-0.3010	NA	-0.1848	-0.2970	-0.3003	-0.3000	-0.2967
238	QG-2	-0.0900	NA	-0.1528	-0.1001	-0.1027	-0.1058	-0.1017
239	QG-3	-0.1000	-0.1028	-0.0762	-0.1028	-0.1038	-0.1028	-0.1048
240	QG-4	-0.2701	-0.2755	-0.3122	-0.2755	-0.2745	-0.2745	-0.2735
241	QG-5	0.0000	NA	-0.2154	-0.0960	0.0070	-0.0158	0.0163
242	QG-6	-0.0607	NA	-0.0384	-0.0680	-0.0638	-0.0667	-0.0677
243	QG-7	-0.0200	NA	-0.0087	-0.0197	-0.0217	-0.0197	-0.0197
244	QG-8	0.6314	0.6283	0.6554	0.6283	0.6293	0.6372	0.6283
245	QG-9	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
246	QG-10	-0.5104	NA	-0.5109	-0.4485	-0.5226	-0.5074	-0.5224
247	QG-11	-0.2300	NA	-0.4271	-0.2663	-0.2121	-0.2165	-0.2163
248	QG-12	0.8129	0.8385	0.8275	0.8385	0.8375	0.8341	0.8385
249	QG-13	-0.1600	0.1639	0.0280	-0.1074	-0.1629	-0.1636	-0.1563
250	QG-14	-0.0100	NA	-0.0659	-0.0797	-0.0159	-0.0206	-0.0243
251	QG-15	-0.2284	-0.2335	-0.2402	-0.2335	-0.2325	-0.2335	-0.2326

252	QG-16	-0.1000	-0.1035	-0.1104	-0.1035	-0.1045	-0.1065	-0.1035
253	QG-17	-0.0300	NA	-0.0280	-0.0490	-0.0834	-0.0919	-0.0873
254	QG-18	-0.0557	NA	-0.0581	-0.0464	-0.0470	-0.0513	-0.0472
255	QG-19	-0.3927	-0.4078	-0.4094	-0.4078	-0.4068	-0.4078	-0.4058
256	QG-20	-0.0300	-0.0301	-0.0294	-0.0301	-0.0291	-0.0258	-0.0281
257	QG-21	-0.0800	NA	-0.0844	-0.0771	-0.0776	-0.0714	-0.0792
258	QG-22	-0.0500	NA	-0.0693	-0.0617	-0.0504	-0.0496	-0.0490
259	QG-23	-0.0300	NA	0.0345	-0.0075	-0.0362	-0.0304	-0.0348
260	QG-24	-0.1491	-0.1525	-0.1229	-0.1489	-0.1517	-0.1525	-0.1525
261	QG-25	0.5004	0.5166	0.5167	0.5166	0.5156	0.5166	0.5146
262	QG-26	0.1012	NA	0.1475	0.0835	0.1157	0.1054	0.1157
263	QG-27	-0.0902	NA	-0.1469	-0.0712	-0.0923	-0.0886	-0.0905
264	QG-28	-0.0700	NA	-0.0829	-0.0794	-0.0684	-0.0734	-0.0683
265	QG-29	-0.0400	NA	-0.0465	-0.0431	-0.0449	-0.0389	-0.0429
266	QG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	0.0004
267	QG-31	0.0559	0.0579	0.0519	0.0579	0.0569	0.0579	0.0593
268	QG-32	-0.3928	NA	-0.3768	-0.3708	-0.3842	-0.3692	-0.3920
269	QG-33	-0.0900	-0.0883	-0.0909	-0.0883	-0.0873	-0.0883	-0.0903
270	QG-34	-0.4683	NA	-0.5042	-0.3211	-0.4462	-0.4199	-0.4425
271	QG-35	-0.0900	-0.0909	-0.0902	-0.0909	-0.0899	-0.0909	-0.0889
272	QG-36	-0.0927	-0.0959	-0.0969	-0.0959	-0.0949	-0.0936	-0.0934
273	QG-37	0.0000	NA	0.1814	0.0922	0.0039	0.0016	-0.0008
274	QG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
275	QG-39	-0.1100	NA	-0.1602	-0.1328	-0.1141	-0.1135	-0.1138
276	QG-40	0.0545	NA	0.0462	0.0543	0.0574	0.0604	0.0591
277	QG-41	-0.1000	NA	-0.0910	-0.0871	-0.0990	-0.0957	-0.0971
278	QG-42	0.1803	0.1818	0.1817	0.1818	0.1828	0.1818	0.1838
279	QG-43	-0.0700	NA	-0.0654	-0.1595	-0.0710	-0.0767	-0.0694
280	QG-44	-0.0800	-0.0780	-0.0812	-0.2105	-0.0790	-0.0875	-0.0780
281	QG-45	-0.2200	NA	-0.2352	-0.0406	-0.2136	-0.2163	-0.2139
282	QG-46	-0.1503	-0.1522	-0.1512	-0.1522	-0.1524	-0.1497	-0.1522
283	QG-47	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
284	QG-48	-0.1100	NA	-0.1231	-0.1200	-0.1117	-0.1050	-0.1130
285	QG-49	0.8585	0.8283	0.8165	0.8283	0.8293	0.8337	0.8283
286	QG-50	-0.0400	NA	-0.0971	-0.0083	-0.0404	-0.0351	-0.0419
287	QG-51	-0.0800	NA	-0.0621	-0.0786	-0.0762	-0.0671	-0.0767
288	QG-52	-0.0500	-0.0487	-0.0528	-0.0487	-0.0497	-0.0487	-0.0507
289	QG-53	-0.1100	-0.1082	-0.1225	-0.1242	-0.1092	-0.1114	-0.1098
290	QG-54	-0.2810	-0.2778	-0.2816	-0.2778	-0.2788	-0.2810	-0.2778
291	QG-55	-0.1734	-0.1737	-0.1792	-0.1737	-0.1727	-0.1737	-0.1717
292	QG-56	-0.2029	NA	-0.2069	-0.1778	-0.2075	-0.2148	-0.2036
293	QG-57	-0.0300	NA	-0.0789	-0.0876	-0.0230	-0.0333	-0.0236

294	QG-58	-0.0300	NA	-0.0264	-0.0267	-0.0298	-0.0267	-0.0290
295	QG-59	-0.3617	NA	-0.2887	-0.3516	-0.3680	-0.3578	-0.3733
296	QG-60	-0.0300	NA	-0.0330	-0.0183	-0.0238	-0.0261	-0.0314
297	QG-61	-0.4039	-0.3930	-0.3943	-0.3930	-0.3940	-0.3930	-0.3930
298	QG-62	-0.1274	NA	-0.1451	-0.1636	-0.1478	-0.1523	-0.1410
299	QG-63	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0003
300	QG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
301	QG-65	0.8151	NA	0.7570	0.6987	0.8197	0.7958	0.8211
302	QG-66	-0.1996	-0.2026	-0.1999	-0.2026	-0.2016	-0.1949	-0.2026
303	QG-67	-0.0700	NA	-0.0656	-0.0645	-0.0662	-0.0660	-0.0631
304	QG-68	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
305	QG-69	-0.8242	NA	-0.8122	-0.8109	-0.8016	-0.7967	-0.7933
306	QG-70	-0.1033	-0.1048	-0.0998	-0.1048	-0.1038	-0.1033	-0.1048
307	QG-71	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
308	QG-72	-0.1113	NA	-0.0745	-0.1041	-0.1092	-0.1044	-0.1102
309	QG-73	0.0965	NA	0.1043	0.1459	0.0969	0.1047	0.0959
310	QG-74	-0.3263	NA	-0.3426	-0.3449	-0.3289	-0.3307	-0.3267
311	QG-75	-0.1100	NA	-0.1463	-0.1424	-0.1193	-0.1193	-0.1198
312	QG-76	-0.3073	NA	-0.3156	-0.3284	-0.3166	-0.3172	-0.3179
313	QG-77	-0.1583	-0.1630	-0.1636	-0.1630	-0.1640	-0.1630	-0.1630
314	QG-78	-0.2600	NA	-0.2249	-0.2031	-0.2293	-0.2276	-0.2344
315	QG-79	-0.3200	-0.3166	-0.3149	-0.3166	-0.3153	-0.3147	-0.3166
316	QG-80	0.7947	NA	0.7975	0.8561	0.7837	0.7863	0.8062
317	QG-81	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0172
318	QG-82	-0.2700	NA	-0.2721	-0.2830	-0.2717	-0.2635	-0.2706
319	QG-83	-0.1000	-0.0972	-0.0928	-0.0972	-0.0962	-0.1010	-0.0972
320	QG-84	-0.0700	NA	-0.0796	-0.0720	-0.0744	-0.0725	-0.0719
321	QG-85	-0.2061	-0.2070	-0.2109	-0.2098	-0.2080	-0.2107	-0.2090
322	QG-86	-0.1000	-0.0989	-0.1019	-0.1032	-0.1023	-0.1023	-0.1023
323	QG-87	0.1102	NA	0.1117	0.1112	0.1122	0.1112	0.1112
324	QG-88	-0.1000	NA	-0.1039	-0.0965	-0.0967	-0.0969	-0.0968
325	QG-89	-0.0590	-0.0584	-0.0627	-0.0584	-0.0594	-0.0584	-0.0584
326	QG-90	0.1731	0.1751	0.1728	0.1751	0.1761	0.1751	0.1751
327	QG-91	-0.1309	NA	-0.1229	-0.1264	-0.1340	-0.1321	-0.1344
328	QG-92	-0.2396	-0.2305	-0.2358	-0.2305	-0.2315	-0.2357	-0.2325
329	QG-93	-0.0700	NA	-0.1031	-0.0842	-0.0822	-0.0775	-0.0772
330	QG-94	-0.1600	NA	-0.1156	-0.1599	-0.1316	-0.1461	-0.1392
331	QG-95	-0.3100	NA	-0.3162	-0.3150	-0.3151	-0.3150	-0.3148
332	QG-96	-0.1500	-0.1482	-0.1498	-0.1482	-0.1482	-0.1482	-0.1482
333	QG-97	-0.0900	-0.0931	-0.0911	-0.0931	-0.0921	-0.0931	-0.0931
334	QG-98	-0.0800	-0.0825	-0.0813	-0.0825	-0.0815	-0.0816	-0.0825
335	QG-99	-0.1754	-0.1684	-0.1719	-0.1684	-0.1694	-0.1684	-0.1684

336	QG-100	0.7755	NA	0.7770	0.8687	0.7623	0.7648	0.7611
337	QG-101	-0.1500	NA	-0.1648	-0.2311	-0.1556	-0.1528	-0.1594
338	QG-102	-0.0300	-0.0298	-0.0333	-0.0298	-0.0308	-0.0331	-0.0298
339	QG-103	0.5942	NA	0.5886	0.6042	0.5828	0.5899	0.5826
340	QG-104	-0.2261	-0.2255	-0.2235	-0.2255	-0.2245	-0.2255	-0.2268
341	QG-105	-0.4433	-0.4472	-0.4438	-0.4472	-0.4462	-0.4444	-0.4472
342	QG-106	-0.1600	NA	-0.1550	-0.1577	-0.1580	-0.1550	-0.1535
343	QG-107	-0.0544	NA	-0.0545	-0.0665	-0.0522	-0.0538	-0.0532
344	QG-108	-0.0100	NA	-0.0170	-0.0156	-0.0155	-0.0181	-0.0181
345	QG-109	-0.0300	NA	-0.0275	-0.0169	-0.0317	-0.0270	-0.0318
346	QG-110	-0.2972	-0.2865	-0.2855	-0.2865	-0.2864	-0.2865	-0.2865
347	QG-111	-0.0184	-0.0186	-0.0211	-0.0487	-0.0196	-0.0186	-0.0186
348	QG-112	0.2851	0.2812	0.2728	0.2812	0.2802	0.2742	0.2812
349	QG-113	0.0675	NA	0.0542	0.0557	0.0674	0.0547	0.0673
350	QG-114	-0.0300	NA	-0.0424	-0.0300	-0.0300	-0.0300	-0.0300
351	QG-115	-0.0700	NA	-0.0629	-0.0710	-0.0709	-0.0683	-0.0709
352	QG-116	0.5132	0.4975	0.4907	0.4934	0.4944	0.4895	0.4934
353	QG-117	-0.0800	-0.0800	-0.0867	-0.0808	-0.0810	-0.0809	-0.0812
354	QG-118	-0.1500	-0.1544	-0.1542	-0.1544	-0.1536	-0.1535	-0.1544
355	PF 1-2	-0.1235	-0.1248	-0.1688	-0.1248	-0.1258	-0.1248	-0.1248
356	PF 1-3	-0.3865	NA	-0.3086	-0.3923	-0.3985	-0.3926	-0.3940
357	PF 4-5	-1.0323	NA	-0.7987	-1.0323	-1.0454	-1.0335	-1.0355
358	PF 3-5	-0.6811	-0.6751	-0.5647	-0.6802	-0.6761	-0.6805	-0.6808
359	PF 5-6	0.8847	0.8771	0.6043	0.8771	0.8761	0.8770	0.8798
360	PF 6-7	0.3554	0.3614	0.2558	0.3614	0.3604	0.3614	0.3614
361	PF 8-9	-4.4064	NA	-4.4074	-4.3908	-4.3891	-4.3909	-4.3912
362	PF 8-5	3.3847	NA	3.4622	3.3606	3.3736	3.3734	3.3874
363	PF 9-10	-4.4525	-4.4367	-4.4532	-4.4367	-4.4357	-4.4367	-4.4367
364	PF 4-11	0.6423	-0.6419	0.3058	0.6364	0.6486	0.6377	0.6381
365	PF 5-11	0.7722	0.7812	0.4044	0.7664	0.7802	0.7678	0.7684
366	PF 11-12	0.3429	NA	0.5076	0.3458	0.1819	0.3440	0.3458
367	PF 2-12	-0.3245	-0.3309	-0.3249	-0.3309	-0.3632	-0.3309	-0.3309
368	PF 3-12	-0.0979	NA	-0.1490	-0.0996	-0.1109	-0.0996	-0.0992
369	PF 7-12	0.1648	0.1617	0.0216	0.1617	0.0963	0.1640	0.1617
370	PF 11-13	0.3509	NA	0.3847	0.3479	0.3492	0.3481	0.3490
371	PF 12-14	0.1831	0.1837	0.1763	0.1837	0.2331	0.1837	0.1837
372	PF 13-15	0.0077	NA	0.0570	0.0069	0.0088	0.0069	0.0078
373	PF 14-15	0.0424	0.0422	0.1011	0.0390	0.0412	0.0400	0.0411
374	PF 12-16	0.0751	NA	0.1070	0.0714	-0.2520	0.0715	0.0723
375	PF 15-17	-1.0386	NA	-1.0079	-1.0468	-1.0383	-1.0420	-1.0392
376	PF 16-17	-0.1751	NA	-0.1184	-0.1768	-0.0065	-0.1767	-0.1759
377	PF 17-18	0.8027	0.8065	0.8100	0.8065	0.8055	0.8065	0.8065

378	PF 18-19	0.1939	NA	0.1896	0.1972	0.1920	0.1960	0.1919
379	PF 19-20	-0.1062	NA	-0.1010	-0.1122	-0.1103	-0.1043	-0.1105
380	PF 15-19	0.1153	NA	0.1537	0.1139	0.1165	0.1178	0.1164
381	PF 20-21	-0.2867	NA	-0.2860	-0.2903	-0.2893	-0.2853	-0.2885
382	PF 21-22	-0.4284	-0.4366	-0.4305	-0.4366	-0.4356	-0.4282	-0.4351
383	PF 22-23	-0.5326	NA	-0.5294	-0.5241	-0.5251	-0.5241	-0.5241
384	PF 23-24	0.0828	0.0828	0.0741	0.0828	0.0838	0.0801	0.0828
385	PF 23-25	-1.6256	NA	-1.6519	-1.6523	-1.6516	-1.6526	-1.6520
386	PF 26-25	0.9029	NA	0.8954	0.9028	0.9018	0.8950	0.9013
387	PF 25-27	1.4352	NA	1.4410	1.4511	1.4511	1.4459	1.4495
388	PF 27-28	0.3288	NA	0.3303	0.3318	0.3328	0.3319	0.3318
389	PF 28-29	0.1566	0.1557	0.1532	0.1557	0.1553	0.1529	0.1557
390	PF 30-17	2.3119	2.2708	2.2537	2.3007	2.3137	2.2864	2.3027
391	PF 8-30	0.7416	NA	0.6814	0.7478	0.7341	0.7351	0.7215
392	PF 26-30	2.2371	NA	2.2429	2.2521	2.2579	2.2279	2.2599
393	PF 17-31	0.1477	0.1473	0.1545	0.1490	0.1508	0.1572	0.1508
394	PF 29-31	-0.0842	NA	-0.0847	-0.0806	-0.0836	-0.0846	-0.0831
395	PF 23-32	0.9298	0.9357	0.9330	0.9357	0.9339	0.9279	0.9316
396	PF 31-32	-0.2986	NA	-0.2978	-0.3000	-0.3003	-0.2958	-0.2994
397	PF 27-32	0.1253	NA	0.1255	0.1285	0.1265	0.1283	0.1270
398	PF 15-33	0.0731	NA	0.1024	0.0837	0.0754	0.0759	0.0763
399	PF 19-34	-0.0359	NA	-0.0189	-0.0288	-0.0344	-0.0341	-0.0334
400	PF 35-36	0.0084	NA	0.0082	0.0070	0.0083	0.0071	0.0070
401	PF 35-37	-0.3384	NA	-0.3385	-0.3366	-0.3388	-0.3366	-0.3366
402	PF 33-37	-0.1572	NA	-0.1434	-0.1546	-0.1573	-0.1558	-0.1554
403	PF 34-36	0.3025	0.2981	0.2977	0.2981	0.2979	0.2981	0.2981
404	PF 34-37	-0.9431	NA	-0.9580	-0.9451	-0.9588	-0.9447	-0.9443
405	PF 38-37	2.4337	NA	2.4965	2.4902	2.4510	2.4462	2.4524
406	PF 37-39	0.5491	NA	0.5566	0.5349	0.5369	0.5435	0.5406
407	PF 37-40	0.4402	0.4325	0.4472	0.4325	0.4335	0.4372	0.4354
408	PF 30-38	0.6235	NA	0.6283	0.6555	0.6334	0.6336	0.6345
409	PF 39-40	0.2692	0.2706	0.2706	0.2706	0.2716	0.2706	0.2706
410	PF 40-41	0.1545	0.1569	0.1593	0.1569	0.1579	0.1569	0.1569
411	PF 40-42	-0.1184	NA	-0.1146	-0.1142	-0.1140	-0.1141	-0.1147
412	PF 41-42	-0.2159	NA	-0.2124	-0.2110	-0.2112	-0.2110	-0.2117
413	PF 43-44	-0.1659	-0.1655	-0.1625	-0.1655	-0.1665	-0.1666	-0.1668
414	PF 34-43	0.0141	0.0140	0.0158	0.0140	0.0130	0.0140	0.0140
415	PF 44-45	-0.3277	NA	-0.3222	-0.3255	-0.3274	-0.3266	-0.3267
416	PF 45-46	-0.3633	NA	-0.3677	-0.3644	-0.3630	-0.3602	-0.3639
417	PF 46-47	-0.3111	NA	-0.3157	-0.3108	-0.3104	-0.3092	-0.3111
418	PF 46-48	-0.1476	-0.1475	-0.1486	-0.1475	-0.1474	-0.1470	-0.1481
419	PF 47-49	-0.0954	NA	-0.1022	-0.0971	-0.0976	-0.0978	-0.0975

420	PF 42-49	-0.6487	NA	-0.6510	-0.6486	-0.6480	-0.6486	-0.6492
421	PF 42-49	-0.6487	NA	-0.6510	-0.6486	-0.6480	-0.6486	-0.6492
422	PF 45-49	-0.4970	-0.4872	-0.5051	-0.4967	-0.4968	-0.4942	-0.4978
423	PF 48-49	-0.3490	NA	-0.3649	-0.3492	-0.3502	-0.3492	-0.3492
424	PF 49-50	0.5366	NA	0.7274	0.5281	0.5291	0.5281	0.5302
425	PF 49-51	0.6663	NA	0.5866	0.6747	0.6728	0.6736	0.6705
426	PF 51-52	0.2856	NA	0.2652	0.2885	0.2874	0.2885	0.2885
427	PF 52-53	0.1037	0.1033	0.0793	0.1040	0.1039	0.1033	0.1044
428	PF 53-54	-0.1268	NA	-0.1277	-0.1287	-0.1298	-0.1294	-0.1298
429	PF 49-54	0.3777	NA	0.3199	0.3812	0.3800	0.3803	0.3795
430	PF 49-54	0.3774	NA	0.3202	0.3811	0.3798	0.3800	0.3792
431	PF 54-55	0.0707	0.0714	0.0665	0.0732	0.0723	0.0727	0.0721
432	PF 54-56	0.1853	NA	0.1016	0.1864	0.1874	0.1864	0.1864
433	PF 55-56	-0.2142	NA	-0.2468	-0.2247	-0.2203	-0.2226	-0.2199
434	PF 56-57	-0.2299	-0.2260	-0.4591	-0.2260	-0.2270	-0.2285	-0.2260
435	PF 50-57	0.3588	-0.3629	-0.0466	0.3732	0.3703	0.3702	0.3690
436	PF 56-58	-0.0667	NA	-0.0263	-0.0659	-0.0649	-0.0650	-0.0655
437	PF 51-58	0.1879	0.1886	0.1593	0.1886	0.1876	0.1886	0.1886
438	PF 54-59	-0.3038	NA	-0.2573	-0.3006	-0.3050	-0.3033	-0.3052
439	PF 56-59	-0.2796	NA	-0.2367	-0.2769	-0.2807	-0.2792	-0.2807
440	PF 56-59	-0.2931	NA	-0.2482	-0.2903	-0.2942	-0.2927	-0.2943
441	PF 55-59	-0.3452	NA	-0.2946	-0.3426	-0.3469	-0.3452	-0.3470
442	PF 59-60	-0.4332	-0.4372	-0.4257	-0.4372	-0.4362	-0.4345	-0.4356
443	PF 59-61	-0.5172	NA	-0.5092	-0.5212	-0.5182	-0.5175	-0.5177
444	PF 60-61	-1.1207	NA	-1.1088	-1.1218	-1.0995	-1.1089	-1.1000
445	PF 60-62	-0.0987	-0.1004	-0.0865	-0.0990	-0.0832	-0.0907	-0.0852
446	PF 61-62	0.2549	NA	0.2687	0.2547	0.2703	0.2625	0.2676
447	PF 63-59	1.5177	NA	1.5060	1.5352	1.5161	1.5247	1.5122
448	PF 63-64	-1.5177	NA	-1.5060	-1.5352	-1.5343	-1.5247	-1.5338
449	PF 64-61	0.3054	NA	0.3158	0.3195	0.3105	0.3187	0.3083
450	PF 38-65	-1.8128	NA	-1.8709	-1.8373	-1.8193	-1.8152	-1.8207
451	PF 64-65	-1.8279	-1.8604	-1.8264	-1.8596	-1.8507	-1.8483	-1.8472
452	PF 49-66	-1.3222	NA	-1.3454	-1.3284	-1.3280	-1.3267	-1.3282
453	PF 49-66	-1.3222	NA	-1.3454	-1.3284	-1.3280	-1.3267	-1.3282
454	PF 62-66	-0.3716	NA	-0.3706	-0.3776	-0.3779	-0.3781	-0.3768
455	PF 62-67	-0.2430	-0.2387	-0.2402	-0.2387	-0.2397	-0.2471	-0.2387
456	PF 65-66	0.0854	NA	0.1006	0.0871	0.0861	0.0812	0.0851
457	PF 66-67	0.5316	NA	0.5326	0.5508	0.5499	0.5416	0.5489
458	PF 65-68	0.1418	0.1442	0.1534	0.1442	0.1452	0.1500	0.1442
459	PF 47-69	-0.5594	-0.5525	-0.5702	-0.5628	-0.5609	-0.5606	-0.5612
460	PF 49-69	-0.4654	NA	-0.4733	-0.4677	-0.4662	-0.4659	-0.4665
461	PF 68-69	-1.2580	NA	-1.2430	-1.2432	-1.2422	-1.2466	-1.2432

462	PF 69-70	1.0838	NA	1.0957	1.0846	1.0812	1.0843	1.0809
463	PF 24-70	-0.0622	NA	-0.0744	-0.0647	-0.0627	-0.0661	-0.0627
464	PF 70-71	0.1665	NA	0.1778	0.1687	0.1688	0.1716	0.1671
465	PF 24-72	0.0147	NA	0.0129	0.0149	0.0149	0.0136	0.0145
466	PF 71-72	0.1060	0.1072	0.1151	0.1089	0.1072	0.1119	0.1072
467	PF 71-73	0.0601	0.0592	0.0622	0.0592	0.0602	0.0592	0.0592
468	PF 70-74	0.1621	NA	0.1598	0.1647	0.1631	0.1621	0.1637
469	PF 70-75	-0.0013	NA	-0.0025	0.0026	0.0018	0.0005	0.0021
470	PF 69-75	1.1001	1.1016	1.1050	1.1016	1.1012	1.1019	1.1016
471	PF 74-75	-0.5199	-0.5134	-0.5147	-0.5134	-0.5124	-0.5134	-0.5134
472	PF 76-77	-0.6115	-0.6192	-0.6156	-0.6176	-0.6132	-0.6140	-0.6129
473	PF 69-77	0.6221	NA	0.6184	0.6162	0.6194	0.6188	0.6194
474	PF 75-77	-0.3461	NA	-0.3508	-0.3507	-0.3481	-0.3488	-0.3483
475	PF 77-78	0.4539	NA	0.4666	0.4593	0.4679	0.4661	0.4684
476	PF 78-79	-0.2568	-0.2595	-0.2602	-0.2595	-0.2585	-0.2595	-0.2595
477	PF 77-80	-0.9657	NA	-0.9759	-0.9753	-0.9724	-0.9731	-0.9731
478	PF 77-80	-0.4437	NA	-0.4486	-0.4481	-0.4470	-0.4474	-0.4472
479	PF 79-80	-0.6474	NA	-0.6569	-0.6552	-0.6552	-0.6552	-0.6552
480	PF 68-81	-0.4415	NA	-0.4489	-0.4430	-0.4449	-0.4492	-0.4446
481	PF 81-80	-0.4420	-0.4435	-0.4494	-0.4435	-0.4445	-0.4497	-0.4450
482	PF 77-82	-0.0303	-0.0304	-0.0320	-0.0304	-0.0314	-0.0316	-0.0304
483	PF 82-83	-0.4722	NA	-0.4749	-0.4792	-0.4783	-0.4750	-0.4793
484	PF 83-84	-0.2479	NA	-0.2478	-0.2554	-0.2503	-0.2484	-0.2528
485	PF 83-85	-0.4277	NA	-0.4287	-0.4289	-0.4321	-0.4282	-0.4301
486	PF 84-85	-0.3635	-0.3682	-0.3628	-0.3502	-0.3672	-0.3628	-0.3580
487	PF 85-86	0.1717	NA	0.1709	0.1721	0.1728	0.1721	0.1734
488	PF 86-87	-0.0395	-0.0392	-0.0397	-0.0392	-0.0383	-0.0392	-0.0392
489	PF 85-88	-0.5039	-0.4945	-0.4991	-0.4945	-0.5070	-0.4998	-0.5000
490	PF 85-89	-0.7124	NA	-0.7115	-0.7083	-0.7161	-0.7114	-0.7116
491	PF 88-89	-0.9893	NA	-0.9939	-0.9933	-0.9943	-0.9933	-0.9933
492	PF 89-90	0.5822	NA	0.5850	0.5833	0.5855	0.5850	0.5847
493	PF 89-90	1.1083	NA	1.1138	1.1106	1.1146	1.1137	1.1130
494	PF 90-91	0.0141	NA	0.0092	0.0060	0.0110	0.0106	0.0082
495	PF 89-92	2.0154	NA	2.0137	2.0068	2.0224	2.0114	2.0137
496	PF 89-92	0.6359	NA	0.6353	0.6333	0.6382	0.6347	0.6354
497	PF 91-92	-0.0860	-0.0850	-0.0876	-0.0850	-0.0860	-0.0892	-0.0862
498	PF 92-93	0.5762	0.5728	0.5741	0.5728	0.5738	0.5728	0.5728
499	PF 92-94	0.5217	NA	0.5233	0.5230	0.5293	0.5232	0.5250
500	PF 93-94	0.4472	NA	0.4514	0.4533	0.4660	0.4543	0.4580
501	PF 94-95	0.4086	0.4122	0.4114	0.4122	0.4112	0.4122	0.4107
502	PF 80-96	0.1897	NA	0.1905	0.1911	0.1905	0.1906	0.1911
503	PF 82-96	-0.0994	-0.0979	-0.1016	-0.1011	-0.1013	-0.1015	-0.1016

504	PF 94-96	0.1979	NA	0.1977	0.1965	0.1972	0.1970	0.1971
505	PF 80-97	0.2642	NA	0.2649	0.2649	0.2647	0.2643	0.2655
506	PF 80-98	0.2895	NA	0.2902	0.2930	0.2914	0.2902	0.2912
507	PF 80-99	0.1956	NA	0.1969	0.1988	0.1975	0.1978	0.1980
508	PF 92-100	0.3150	0.3211	0.3162	0.3167	0.3192	0.3158	0.3164
509	PF 94-100	0.0428	NA	0.0438	0.0435	0.0440	0.0431	0.0430
510	PF 95-96	-0.0138	-0.0136	-0.0162	-0.0189	-0.0169	-0.0180	-0.0167
511	PF 96-97	-0.1110	NA	-0.1120	-0.1131	-0.1121	-0.1126	-0.1124
512	PF 98-100	-0.0526	-0.0517	-0.0517	-0.0517	-0.0523	-0.0517	-0.0519
513	PF 99-100	-0.2265	-0.2226	-0.2267	-0.2277	-0.2279	-0.2287	-0.2285
514	PF 100-101	-0.1674	-0.1698	-0.1694	-0.1698	-0.1708	-0.1698	-0.1698
515	PF 92-102	0.4465	NA	0.4467	0.4433	0.4511	0.4454	0.4475
516	PF 101-102	-0.3898	-0.3877	-0.3894	-0.3877	-0.3942	-0.3896	-0.3902
517	PF 100-103	1.2175	NA	1.2123	1.2135	1.2125	1.2136	1.2136
518	PF 100-104	0.5618	NA	0.5571	0.5586	0.5581	0.5583	0.5584
519	PF 103-104	0.3245	NA	0.3200	0.3220	0.3212	0.3211	0.3213
520	PF 103-105	0.4335	NA	0.4290	0.4315	0.4305	0.4307	0.4307
521	PF 100-106	0.6036	0.5930	0.5987	0.6008	0.6001	0.6007	0.6008
522	PF 104-105	0.4858	NA	0.4858	0.4871	0.4869	0.4879	0.4877
523	PF 105-105	0.0886	NA	0.0855	0.0877	0.0867	0.0877	0.0877
524	PF 105-107	0.2675	NA	0.2676	0.2686	0.2673	0.2686	0.2686
525	PF 105-108	0.2397	0.2396	0.2397	0.2396	0.2406	0.2396	0.2396
526	PF 106-107	0.2398	NA	0.2409	0.2413	0.2403	0.2413	0.2413
527	PF 108-109	0.2177	0.2154	0.2153	0.2154	0.2160	0.2154	0.2154
528	PF 103-110	0.6060	NA	0.6026	0.6037	0.6048	0.6043	0.6042
529	PF 109-110	0.1371	0.1389	0.1406	0.1411	0.1399	0.1404	0.1389
530	PF 110-111	-0.3570	NA	-0.3543	-0.3536	-0.3538	-0.3537	-0.3537

531	PF 110-112	0.6946	NA	0.6861	0.6862	0.6872	0.6861	0.6860
532	PF 17-113	0.0206	0.0206	0.0220	0.0206	0.0216	0.0206	0.0206
533	PF 32-113	0.0412	NA	0.0354	0.0402	0.0396	0.0319	0.0391
534	PF 32-114	0.0937	NA	0.0947	0.0936	0.0946	0.0936	0.0936
535	PF 27-115	0.2072	0.2104	0.2096	0.2104	0.2094	0.2104	0.2089
536	PF 114-115	0.0136	0.0138	0.0139	0.0138	0.0148	0.0138	0.0138
537	PF 68-116	1.8413	NA	1.8453	1.8304	1.8333	1.8457	1.8322
538	PF 12-117	0.2015	0.2001	0.1837	0.2009	0.2011	0.2012	0.2001
539	PF 75-118	0.4021	0.3946	0.3988	0.4035	0.4014	0.4004	0.4004
540	PF 76-118	-0.0685	-0.0676	-0.0661	-0.0676	-0.0666	-0.0676	-0.0661
541	PT 1-2	0.1245	NA	0.1698	0.1257	0.1267	0.1257	0.1257
542	PT 1-3	0.3890	NA	0.3101	0.3949	0.4012	0.3952	0.3966
543	PT 4-5	1.0343	NA	0.8000	1.0343	1.0474	1.0355	1.0375
544	PT 3-5	0.6935	NA	0.5729	0.6926	0.6883	0.6929	0.6932
545	PT 5-6	-0.8754	NA	-0.6000	-0.8679	-0.8670	-0.8678	-0.8706
546	PT 6-7	-0.3548	NA	-0.2555	-0.3608	-0.3598	-0.3608	-0.3608
547	PT 8-9	4.4525	NA	4.4532	4.4367	4.4347	4.4367	4.4369
548	PT 8-5	-3.3847	NA	-3.4622	-3.3606	-3.3736	-3.3734	-3.3874
549	PT 9-10	4.5000	NA	4.5000	4.4834	4.4826	4.4838	4.4837
550	PT 4-11	-0.6336	NA	-0.3039	-0.6279	-0.6398	-0.6291	-0.6296
551	PT 5-11	-0.7602	NA	-0.4011	-0.7544	-0.7679	-0.7558	-0.7565
552	PT 11-12	-0.3415	-0.3444	-0.5053	-0.3444	-0.1810	-0.3426	-0.3444
553	PT 2-12	0.3273	NA	0.3277	0.3339	0.3666	0.3340	0.3339
554	PT 3-12	0.0989	NA	0.1504	0.1007	0.1121	0.1007	0.1002
555	PT 7-12	-0.1645	NA	-0.0216	-0.1614	-0.0962	-0.1637	-0.1614
556	PT 11-13	-0.3477	-0.3450	-0.3814	-0.3450	-0.3460	-0.3450	-0.3458
557	PT 12-14	-0.1824	NA	-0.1756	-0.1828	-0.2319	-0.1829	-0.1829
558	PT 13-15	-0.0077	-0.0078	-0.0567	-0.0069	-0.0088	-0.0069	-0.0078
559	PT 14-15	-0.0421	NA	-0.1004	-0.0388	-0.0409	-0.0397	-0.0408
560	PT 12-16	-0.0749	NA	-0.1067	-0.0712	0.2535	-0.0713	-0.0721
561	PT 15-17	1.0544	1.0682	1.0225	1.0628	1.0540	1.0579	1.0549
562	PT 16-17	0.1766	NA	0.1191	0.1783	0.0065	0.1782	0.1774
563	PT 17-18	-0.7939	NA	-0.8012	-0.7977	-0.7967	-0.7977	-0.7977
564	PT 18-19	-0.1931	-0.1964	-0.1888	-0.1964	-0.1912	-0.1952	-0.1911
565	PT 19-20	0.1067	NA	0.1013	0.1127	0.1107	0.1046	0.1109
566	PT 15-19	-0.1147	NA	-0.1531	-0.1134	-0.1160	-0.1173	-0.1159
567	PT 20-21	0.2884	0.2920	0.2877	0.2920	0.2910	0.2870	0.2902
568	PT 21-22	0.4326	0.4249	0.4346	0.4409	0.4399	0.4323	0.4394
569	PT 22-23	0.5430	0.5341	0.5395	0.5341	0.5351	0.5341	0.5341
570	PT 23-24	-0.0825	NA	-0.0738	-0.0825	-0.0835	-0.0798	-0.0825

571	PT 23-25	1.6676	1.6958	1.6940	1.6952	1.6948	1.6958	1.6953
572	PT 26-25	-0.9029	-0.9028	-0.8954	-0.9028	-0.9018	-0.8950	-0.9013
573	PT 25-27	-1.3713	NA	-1.3775	-1.3864	-1.3859	-1.3812	-1.3844
574	PT 27-28	-0.3266	-0.3295	-0.3281	-0.3295	-0.3305	-0.3297	-0.3295
575	PT 28-29	-0.1558	NA	-0.1525	-0.1550	-0.1546	-0.1522	-0.1550
576	PT 30-17	-2.3119	NA	-2.2537	-2.3007	-2.3137	-2.2864	-2.3027
577	PT 8-30	-0.7381	-0.7443	-0.6784	-0.7443	-0.7305	-0.7316	-0.7180
578	PT 26-30	-2.1973	NA	-2.2037	-2.2119	-2.2175	-2.1885	-2.2194
579	PT 17-31	-0.1457	NA	-0.1526	-0.1472	-0.1489	-0.1554	-0.1488
580	PT 29-31	0.0843	0.0848	0.0849	0.0808	0.0838	0.0848	0.0833
581	PT 23-32	-0.9020	NA	-0.9055	-0.9078	-0.9059	-0.9003	-0.9037
582	PT 31-32	0.3020	NA	0.3010	0.3034	0.3037	0.2991	0.3028
583	PT 27-32	-0.1249	NA	-0.1251	-0.1281	-0.1261	-0.1279	-0.1266
584	PT 15-33	-0.0728	NA	-0.1019	-0.0833	-0.0751	-0.0756	-0.0760
585	PT 19-34	0.0365	0.0360	0.0194	0.0296	0.0350	0.0348	0.0341
586	PT 35-36	-0.0084	NA	-0.0082	-0.0070	-0.0083	-0.0070	-0.0070
587	PT 35-37	0.3399	0.3413	0.3400	0.3380	0.3403	0.3380	0.3380
588	PT 33-37	0.1586	0.1581	0.1446	0.1561	0.1587	0.1573	0.1568
589	PT 34-36	-0.3016	NA	-0.2969	-0.2973	-0.2971	-0.2973	-0.2973
590	PT 34-37	0.9459	NA	0.9611	0.9479	0.9617	0.9475	0.9471
591	PT 38-37	-2.4337	NA	-2.4965	-2.4902	-2.4510	-2.4462	-2.4524
592	PT 37-39	-0.5392	NA	-0.5464	-0.5255	-0.5275	-0.5338	-0.5310
593	PT 37-40	-0.4285	NA	-0.4354	-0.4213	-0.4222	-0.4257	-0.4240
594	PT 30-38	-0.6209	-0.6122	-0.6256	-0.6528	-0.6308	-0.6310	-0.6319
595	PT 39-40	-0.2676	NA	-0.2690	-0.2690	-0.2700	-0.2690	-0.2690
596	PT 40-41	-0.1541	NA	-0.1589	-0.1565	-0.1575	-0.1565	-0.1565
597	PT 40-42	0.1193	0.1197	0.1154	0.1150	0.1148	0.1150	0.1155
598	PT 41-42	0.2181	0.2177	0.2144	0.2131	0.2133	0.2131	0.2139
599	PT 43-44	0.1677	NA	0.1642	0.1673	0.1683	0.1684	0.1686
600	PT 34-43	-0.0141	NA	-0.0156	-0.0133	-0.0129	-0.0139	-0.0139
601	PT 44-45	0.3303	NA	0.3248	0.3281	0.3300	0.3291	0.3293
602	PT 45-46	0.3687	NA	0.3733	0.3699	0.3684	0.3655	0.3693
603	PT 46-47	0.3148	0.3201	0.3195	0.3144	0.3140	0.3128	0.3147
604	PT 46-48	0.1490	NA	0.1500	0.1488	0.1488	0.1484	0.1495
605	PT 47-49	0.0957	NA	0.1025	0.0975	0.0980	0.0982	0.0979
606	PT 42-49	0.6804	0.6887	0.6830	0.6802	0.6795	0.6802	0.6808
607	PT 42-49	0.6804	0.6755	0.6830	0.6802	0.6795	0.6802	0.6808
608	PT 45-49	0.5144	NA	0.5231	0.5140	0.5140	0.5114	0.5151
609	PT 48-49	0.3511	0.3514	0.3673	0.3514	0.3524	0.3514	0.3514
610	PT 49-50	-0.5288	-0.5205	-0.7127	-0.5205	-0.5215	-0.5205	-0.5226
611	PT 49-51	-0.6435	-0.6555	-0.5687	-0.6512	-0.6497	-0.6504	-0.6475
612	PT 51-52	-0.2837	-0.2866	-0.2636	-0.2866	-0.2855	-0.2866	-0.2866

613	PT 52-53	-0.1032	NA	-0.0789	-0.1035	-0.1034	-0.1028	-0.1039
614	PT 53-54	0.1274	NA	0.1283	0.1292	0.1303	0.1299	0.1303
615	PT 49-54	-0.3658	-0.3600	-0.3110	-0.3690	-0.3680	-0.3682	-0.3675
616	PT 49-54	-0.3638	NA	-0.3101	-0.3671	-0.3660	-0.3662	-0.3655
617	PT 54-55	-0.0706	NA	-0.0664	-0.0731	-0.0722	-0.0726	-0.0720
618	PT 54-56	-0.1852	-0.1863	-0.1016	-0.1863	-0.1873	-0.1863	-0.1863
619	PT 55-56	0.2145	0.2185	0.2471	0.2250	0.2205	0.2229	0.2201
620	PT 56-57	0.2321	NA	0.4670	0.2280	0.2292	0.2307	0.2281
621	PT 50-57	-0.3521	NA	0.0472	-0.3657	-0.3633	-0.3631	-0.3621
622	PT 56-58	0.0669	0.0661	0.0264	0.0661	0.0651	0.0652	0.0657
623	PT 51-58	-0.1869	NA	-0.1586	-0.1876	-0.1866	-0.1876	-0.1876
624	PT 54-59	0.3090	0.3031	0.2612	0.3058	0.3102	0.3085	0.3104
625	PT 56-59	0.2867	NA	0.2418	0.2839	0.2878	0.2863	0.2879
626	PT 56-59	0.3007	0.3039	0.2537	0.2978	0.3019	0.3003	0.3019
627	PT 55-59	0.3516	NA	0.2994	0.3489	0.3533	0.3516	0.3535
628	PT 59-60	0.4394	NA	0.4318	0.4436	0.4425	0.4408	0.4419
629	PT 59-61	0.5264	0.5182	0.5181	0.5306	0.5275	0.5267	0.5269
630	PT 60-61	1.1241	1.1018	1.1121	1.1253	1.1028	1.1122	1.1033
631	PT 60-62	0.0989	NA	0.0866	0.0991	0.0834	0.0909	0.0853
632	PT 61-62	-0.2542	NA	-0.2680	-0.2540	-0.2696	-0.2618	-0.2669
633	PT 63-59	-1.5177	-1.5040	-1.5060	-1.5352	-1.5161	-1.5247	-1.5122
634	PT 63-64	1.5225	1.5402	1.5106	1.5402	1.5392	1.5296	1.5387
635	PT 64-61	-0.3054	NA	-0.3158	-0.3195	-0.3105	-0.3187	-0.3083
636	PT 38-65	1.8449	NA	1.9045	1.8701	1.8515	1.8473	1.8529
637	PT 64-65	1.8378	NA	1.8362	1.8700	1.8608	1.8585	1.8573
638	PT 49-66	1.3522	1.3473	1.3766	1.3588	1.3582	1.3569	1.3585
639	PT 49-66	1.3522	NA	1.3766	1.3588	1.3582	1.3569	1.3585
640	PT 62-66	0.3793	0.3833	0.3781	0.3856	0.3858	0.3861	0.3847
641	PT 62-67	0.2450	NA	0.2421	0.2406	0.2416	0.2491	0.2406
642	PT 65-66	-0.0854	-0.0871	-0.1006	-0.0871	-0.0861	-0.0812	-0.0851
643	PT 66-67	-0.5250	-0.5210	-0.5260	-0.5438	-0.5428	-0.5348	-0.5419
644	PT 65-68	-0.1418	NA	-0.1534	-0.1442	-0.1452	-0.1499	-0.1442
645	PT 47-69	0.5868	NA	0.5985	0.5906	0.5884	0.5880	0.5887
646	PT 49-69	0.4878	0.4913	0.4963	0.4903	0.4886	0.4882	0.4889
647	PT 68-69	1.2580	1.2432	1.2430	1.2432	1.2422	1.2466	1.2432
648	PT 69-70	-1.0494	NA	-1.0611	-1.0504	-1.0471	-1.0500	-1.0468
649	PT 24-70	0.0622	0.0617	0.0744	0.0648	0.0627	0.0661	0.0628
650	PT 70-71	-0.1661	NA	-0.1773	-0.1681	-0.1684	-0.1711	-0.1667
651	PT 24-72	-0.0145	-0.0148	-0.0127	-0.0148	-0.0147	-0.0135	-0.0143
652	PT 71-72	-0.1055	NA	-0.1145	-0.1083	-0.1066	-0.1113	-0.1067
653	PT 71-73	-0.0600	NA	-0.0620	-0.0590	-0.0601	-0.0591	-0.0591
654	PT 70-74	-0.1601	-0.1601	-0.1575	-0.1624	-0.1611	-0.1601	-0.1617

655	PT 70-75	0.0019	NA	0.0034	-0.0017	-0.0011	0.0002	-0.0014
656	PT 69-75	-1.0516	NA	-1.0561	-1.0527	-1.0526	-1.0532	-1.0529
657	PT 74-75	0.5236	NA	0.5183	0.5170	0.5159	0.5170	0.5169
658	PT 76-77	0.6321	NA	0.6365	0.6390	0.6340	0.6349	0.6337
659	PT 69-77	-0.6105	-0.6042	-0.6070	-0.6050	-0.6079	-0.6073	-0.6079
660	PT 75-77	0.3541	0.3483	0.3591	0.3590	0.3563	0.3570	0.3565
661	PT 77-78	-0.4532	NA	-0.4658	-0.4585	-0.4671	-0.4653	-0.4676
662	PT 78-79	0.2574	NA	0.2607	0.2600	0.2590	0.2600	0.2600
663	PT 77-80	0.9834	NA	0.9938	0.9934	0.9902	0.9909	0.9910
664	PT 77-80	0.4505	NA	0.4555	0.4550	0.4538	0.4542	0.4541
665	PT 79-80	0.6550	0.6666	0.6647	0.6629	0.6629	0.6629	0.6629
666	PT 68-81	0.4420	NA	0.4494	0.4435	0.4455	0.4497	0.4452
667	PT 81-80	0.4420	NA	0.4494	0.4435	0.4445	0.4497	0.4450
668	PT 77-82	0.0317	NA	0.0335	0.0319	0.0328	0.0330	0.0318
669	PT 82-83	0.4756	0.4827	0.4783	0.4827	0.4817	0.4784	0.4827
670	PT 83-84	0.2535	NA	0.2536	0.2613	0.2560	0.2540	0.2586
671	PT 83-85	0.4367	NA	0.4377	0.4379	0.4412	0.4372	0.4391
672	PT 84-85	0.3679	NA	0.3672	0.3543	0.3717	0.3672	0.3623
673	PT 85-86	-0.1705	-0.1726	-0.1697	-0.1709	-0.1716	-0.1709	-0.1721
674	PT 86-87	0.0400	0.0398	0.0402	0.0398	0.0388	0.0398	0.0398
675	PT 85-88	0.5093	NA	0.5044	0.4996	0.5124	0.5051	0.5053
676	PT 85-89	0.7249	NA	0.7240	0.7206	0.7287	0.7239	0.7240
677	PT 88-89	1.0033	1.0074	1.0080	1.0074	1.0084	1.0074	1.0074
678	PT 89-90	-0.5648	NA	-0.5675	-0.5659	-0.5680	-0.5675	-0.5672
679	PT 89-90	-1.0793	-1.0881	-1.0845	-1.0815	-1.0855	-1.0846	-1.0840
680	PT 90-91	-0.0140	NA	-0.0091	-0.0059	-0.0109	-0.0105	-0.0081
681	PT 89-92	-1.9756	NA	-1.9740	-1.9674	-1.9825	-1.9718	-1.9741
682	PT 89-92	-0.6202	NA	-0.6196	-0.6177	-0.6223	-0.6190	-0.6197
683	PT 91-92	0.0864	NA	0.0880	0.0854	0.0864	0.0896	0.0866
684	PT 92-93	-0.5672	NA	-0.5652	-0.5639	-0.5649	-0.5639	-0.5639
685	PT 92-94	-0.5075	-0.5024	-0.5089	-0.5087	-0.5148	-0.5090	-0.5106
686	PT 93-94	-0.4418	NA	-0.4457	-0.4477	-0.4601	-0.4487	-0.4524
687	PT 94-95	-0.4062	NA	-0.4090	-0.4098	-0.4088	-0.4098	-0.4083
688	PT 80-96	-0.1866	NA	-0.1874	-0.1880	-0.1875	-0.1875	-0.1880
689	PT 82-96	0.0996	NA	0.1018	0.1013	0.1014	0.1017	0.1018
690	PT 94-96	-0.1966	-0.1949	-0.1965	-0.1952	-0.1959	-0.1957	-0.1958
691	PT 80-97	-0.2618	NA	-0.2625	-0.2624	-0.2623	-0.2619	-0.2631
692	PT 80-98	-0.2874	-0.2837	-0.2881	-0.2909	-0.2893	-0.2882	-0.2891
693	PT 80-99	-0.1935	NA	-0.1947	-0.1967	-0.1954	-0.1956	-0.1958
694	PT 92-100	-0.3071	NA	-0.3082	-0.3086	-0.3112	-0.3079	-0.3086
695	PT 94-100	-0.0387	-0.0390	-0.0397	-0.0390	-0.0400	-0.0390	-0.0390
696	PT 95-96	0.0145	NA	0.0170	0.0197	0.0177	0.0188	0.0175

697	PT 96-97	0.1118	0.1119	0.1128	0.1140	0.1129	0.1135	0.1132
698	PT 98-100	0.0528	NA	0.0519	0.0518	0.0525	0.0519	0.0521
699	PT 99-100	0.2274	NA	0.2276	0.2286	0.2289	0.2296	0.2294
700	PT 100-101	0.1698	NA	0.1719	0.1730	0.1732	0.1722	0.1722
701	PT 92-102	-0.4439	NA	-0.4441	-0.4408	-0.4485	-0.4428	-0.4449
702	PT 101-102	0.3939	NA	0.3935	0.3917	0.3984	0.3937	0.3943
703	PT 100-103	-1.1940	-1.1903	-1.1890	-1.1903	-1.1893	-1.1903	-1.1903
704	PT 100-104	-0.5473	NA	-0.5429	-0.5442	-0.5438	-0.5439	-0.5440
705	PT 103-104	-0.3185	NA	-0.3142	-0.3161	-0.3154	-0.3153	-0.3154
706	PT 103-105	-0.4225	NA	-0.4182	-0.4206	-0.4196	-0.4198	-0.4199
707	PT 100-106	-0.5814	NA	-0.5769	-0.5788	-0.5781	-0.5787	-0.5788
708	PT 104-105	-0.4833	-0.4854	-0.4833	-0.4846	-0.4844	-0.4854	-0.4852
709	PT 105-105	-0.0885	-0.0875	-0.0854	-0.0875	-0.0865	-0.0876	-0.0875
710	PT 105-107	-0.2635	NA	-0.2635	-0.2646	-0.2632	-0.2645	-0.2645
711	PT 105-108	-0.2377	NA	-0.2379	-0.2377	-0.2387	-0.2377	-0.2377
712	PT 106-107	-0.2365	-0.2379	-0.2376	-0.2379	-0.2369	-0.2379	-0.2379
713	PT 108-109	-0.2171	-0.2143	-0.2147	-0.2147	-0.2153	-0.2147	-0.2147
714	PT 103-110	-0.5915	NA	-0.5883	-0.5893	-0.5904	-0.5899	-0.5899
715	PT 109-110	-0.1361	NA	-0.1395	-0.1402	-0.1388	-0.1393	-0.1378
716	PT 110-111	0.3600	NA	0.3572	0.3566	0.3568	0.3566	0.3566
717	PT 110-112	-0.6800	NA	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
718	PT 17-113	-0.0205	NA	-0.0219	-0.0206	-0.0216	-0.0206	-0.0206
719	PT 32-113	-0.0395	-0.0390	-0.0339	-0.0388	-0.0380	-0.0306	-0.0375
720	PT 32-114	-0.0936	-0.0934	-0.0945	-0.0934	-0.0944	-0.0934	-0.0934
721	PT 27-115	-0.2064	NA	-0.2088	-0.2096	-0.2086	-0.2096	-0.2081

722	PT 114-115	-0.0136	NA	-0.0139	-0.0138	-0.0148	-0.0138	-0.0138
723	PT 68-116	-1.8400	-1.8256	-1.8440	-1.8291	-1.8321	-1.8444	-1.8310
724	PT 12-117	-0.2000	NA	-0.1825	-0.1994	-0.1996	-0.1997	-0.1986
725	PT 75-118	-0.3987	NA	-0.3954	-0.4000	-0.3980	-0.3970	-0.3970
726	PT 76-118	0.0687	NA	0.0663	0.0679	0.0669	0.0679	0.0664
727	QF 1-2	-0.1304	-0.1267	-0.0647	-0.1267	-0.1277	-0.1267	-0.1267
728	QF 1-3	-0.1706	NA	-0.1201	-0.1703	-0.1726	-0.1732	-0.1700
729	QF 4-5	-0.2679	NA	-0.2946	-0.2722	-0.2714	-0.2713	-0.2704
730	QF 3-5	-0.1449	-0.1483	-0.0964	-0.1474	-0.1493	-0.1489	-0.1483
731	QF 5-6	0.0411	0.0415	-0.0094	0.0463	0.0425	0.0448	0.0458
732	QF 6-7	-0.0477	-0.0493	-0.0530	-0.0493	-0.0483	-0.0493	-0.0493
733	QF 8-9	-0.8973	NA	-0.9444	-0.9890	-0.9120	-0.9134	-0.9092
734	QF 8-5	1.2473	NA	1.3714	1.3560	1.2466	1.2729	1.2412
735	QF 9-10	-0.2443	-0.2443	-0.2701	-0.3276	-0.2453	-0.2547	-0.2443
736	QF 4-11	-0.0022	-0.0021	-0.0176	-0.0033	-0.0031	-0.0032	-0.0031
737	QF 5-11	0.0297	0.0290	0.0134	0.0290	0.0291	0.0290	0.0290
738	QF 11-12	-0.3514	NA	-0.3723	-0.3381	-0.3417	-0.3420	-0.3402
739	QF 2-12	-0.2001	-0.2066	-0.1966	-0.2066	-0.2100	-0.2122	-0.2080
740	QF 3-12	-0.1240	NA	-0.0945	-0.1242	-0.1257	-0.1256	-0.1249
741	QF 7-12	-0.0651	-0.0664	-0.0577	-0.0664	-0.0674	-0.0664	-0.0664
742	QF 11-13	0.1141	NA	-0.0417	0.0634	0.1198	0.1174	0.1163
743	QF 12-14	0.0262	0.0261	0.0567	0.0658	0.0354	0.0341	0.0423
744	QF 13-15	-0.0384	NA	-0.0061	-0.0357	-0.0354	-0.0386	-0.0324
745	QF 14-15	0.0314	-0.0323	0.0064	0.0008	0.0333	0.0286	0.0331
746	QF 12-16	0.0430	NA	0.0400	0.0325	0.0537	0.0488	0.0525
747	QF 15-17	-0.2427	NA	-0.2464	-0.2446	-0.2361	-0.2349	-0.2338
748	QF 16-17	-0.0368	NA	-0.0503	-0.0508	-0.0354	-0.0376	-0.0308
749	QF 17-18	0.2476	0.2400	0.2510	0.2400	0.2410	0.2400	0.2400
750	QF 18-19	0.1683	NA	0.1695	0.1701	0.1704	0.1650	0.1692
751	QF 19-20	0.0517	NA	0.0457	0.0484	0.0486	0.0377	0.0486
752	QF 15-19	0.1572	NA	0.1618	0.1469	0.1590	0.1516	0.1585
753	QF 20-21	0.0471	NA	0.0425	0.0438	0.0450	0.0377	0.0460
754	QF 21-22	-0.0210	-0.0214	-0.0294	-0.0214	-0.0208	-0.0216	-0.0214
755	QF 22-23	-0.0676	NA	-0.0946	-0.0802	-0.0683	-0.0675	-0.0674
756	QF 23-24	0.1042	0.1059	0.1050	0.1059	0.1049	0.1060	0.1059
757	QF 23-25	-0.2616	NA	-0.2564	-0.2507	-0.2676	-0.2609	-0.2674
758	QF 26-25	0.2158	NA	0.2208	0.1885	0.2202	0.2069	0.2212
759	QF 25-27	0.3006	NA	0.3303	0.2969	0.3082	0.3034	0.3080
760	QF 27-28	-0.0059	NA	0.0021	0.0052	-0.0047	-0.0007	-0.0057
761	QF 28-29	-0.0657	-0.0639	-0.0701	-0.0639	-0.0629	-0.0639	-0.0639
762	QF 30-17	0.9297	0.9583	0.9290	0.9416	0.9573	0.9583	0.9583

763	QF 8-30	0.2815	NA	0.2284	0.2613	0.2946	0.2777	0.2962
764	QF 26-30	-0.1146	NA	-0.0733	-0.1050	-0.1045	-0.1014	-0.1055
765	QF 17-31	0.1152	0.1136	0.1141	0.1033	0.1126	0.1012	0.1120
766	QF 29-31	-0.0864	NA	-0.0969	-0.0876	-0.0885	-0.0834	-0.0875
767	QF 23-32	0.0505	0.0496	0.0842	0.0496	0.0506	0.0496	0.0518
768	QF 31-32	0.1240	NA	0.1091	0.1137	0.1204	0.1152	0.1232
769	QF 27-32	0.0176	NA	-0.0021	0.0184	0.0166	0.0159	0.0185
770	QF 15-33	-0.0442	NA	-0.0490	-0.0643	-0.0515	-0.0544	-0.0505
771	QF 19-34	-0.1040	NA	-0.1088	-0.1242	-0.1109	-0.1140	-0.1117
772	QF 35-36	0.0404	NA	0.0472	0.0374	0.0398	0.0373	0.0393
773	QF 35-37	-0.1304	NA	-0.1374	-0.1284	-0.1297	-0.1282	-0.1282
774	QF 33-37	-0.1049	NA	-0.1107	-0.1236	-0.1095	-0.1135	-0.1115
775	QF 34-36	0.0470	0.0486	0.0439	0.0529	0.0496	0.0508	0.0486
776	QF 34-37	-0.4420	NA	-0.4946	-0.4115	-0.4303	-0.4168	-0.4255
777	QF 38-37	1.1360	NA	1.1039	1.0626	1.1271	1.1147	1.1253
778	QF 37-39	0.0298	NA	0.0777	0.0476	0.0303	0.0294	0.0293
779	QF 37-40	-0.0368	-0.0380	-0.0088	-0.0268	-0.0370	-0.0380	-0.0380
780	QF 30-38	0.1903	NA	0.2198	0.1701	0.1845	0.1788	0.1845
781	QF 39-40	-0.0870	-0.0899	-0.0899	-0.0899	-0.0889	-0.0899	-0.0899
782	QF 40-41	0.0119	0.0116	0.0170	0.0116	0.0126	0.0116	0.0116
783	QF 40-42	-0.0645	NA	-0.0527	-0.0553	-0.0631	-0.0616	-0.0627
784	QF 41-42	-0.0779	NA	-0.0637	-0.0652	-0.0761	-0.0739	-0.0752
785	QF 43-44	-0.0133	-0.0136	0.0101	-0.0136	-0.0126	-0.0102	-0.0119
786	QF 34-43	0.0163	0.0169	0.0349	0.1083	0.0179	0.0262	0.0169
787	QF 44-45	0.0548	NA	0.0773	-0.0789	0.0572	0.0504	0.0588
788	QF 45-46	-0.0357	NA	-0.0326	-0.0146	-0.0314	-0.0365	-0.0308
789	QF 46-47	-0.0122	NA	-0.0148	-0.0027	-0.0113	-0.0119	-0.0110
790	QF 46-48	-0.0583	-0.0561	-0.0549	-0.0483	-0.0565	-0.0584	-0.0561
791	QF 47-49	-0.1084	NA	-0.1023	-0.0974	-0.1042	-0.1051	-0.1042
792	QF 42-49	0.0524	NA	0.0668	0.0649	0.0558	0.0571	0.0569
793	QF 42-49	0.0524	NA	0.0668	0.0649	0.0558	0.0571	0.0569
794	QF 45-49	-0.0208	-0.0209	-0.0173	0.0041	-0.0158	-0.0205	-0.0151
795	QF 48-49	0.0321	NA	0.0210	0.0317	0.0326	0.0371	0.0316
796	QF 49-50	0.1343	NA	0.2027	0.1326	0.1314	0.1324	0.1325
797	QF 49-51	0.2044	NA	0.1849	0.2100	0.2019	0.1989	0.2019
798	QF 51-52	0.0625	NA	0.0700	0.0675	0.0622	0.0648	0.0630
799	QF 52-53	0.0199	0.0198	0.0255	0.0261	0.0200	0.0235	0.0198
800	QF 53-54	-0.0555	NA	-0.0615	-0.0639	-0.0546	-0.0534	-0.0554
801	QF 49-54	0.1307	NA	0.1176	0.1349	0.1302	0.1320	0.1298
802	QF 49-54	0.1120	NA	0.1016	0.1160	0.1113	0.1131	0.1110
803	QF 54-55	0.0146	0.0147	0.0139	0.0147	0.0147	0.0150	0.0146
804	QF 54-56	0.0435	NA	0.0514	0.0433	0.0443	0.0467	0.0433

805	QF 55-56	-0.0582	NA	-0.0504	-0.0579	-0.0579	-0.0575	-0.0580
806	QF 56-57	-0.0910	-0.0938	-0.0351	-0.0616	-0.0947	-0.0903	-0.0938
807	QF 50-57	0.0914	0.0878	0.0832	0.1220	0.0888	0.0951	0.0883
808	QF 56-58	-0.0369	NA	-0.0465	-0.0397	-0.0380	-0.0443	-0.0377
809	QF 51-58	0.0316	0.0313	0.0362	0.0313	0.0323	0.0357	0.0313
810	QF 54-59	-0.0751	NA	-0.0884	-0.0757	-0.0746	-0.0757	-0.0737
811	QF 56-59	-0.0417	NA	-0.0584	-0.0425	-0.0412	-0.0424	-0.0404
812	QF 56-59	-0.0391	NA	-0.0568	-0.0399	-0.0385	-0.0398	-0.0377
813	QF 55-59	-0.0826	NA	-0.0968	-0.0832	-0.0821	-0.0834	-0.0811
814	QF 59-60	0.0357	0.0364	0.0446	0.0373	0.0354	0.0364	0.0351
815	QF 59-61	0.0503	NA	0.0584	0.0520	0.0497	0.0506	0.0491
816	QF 60-61	0.0852	NA	0.0820	0.0863	0.0843	0.0823	0.0801
817	QF 60-62	-0.0711	-0.0736	-0.0610	-0.0599	-0.0648	-0.0640	-0.0683
818	QF 61-62	-0.1386	NA	-0.1220	-0.1222	-0.1284	-0.1267	-0.1323
819	QF 63-59	0.6748	NA	0.6498	0.6736	0.6779	0.6757	0.6786
820	QF 63-64	-0.6748	NA	-0.6498	-0.6736	-0.6769	-0.6757	-0.6783
821	QF 64-61	0.1399	NA	0.1400	0.1442	0.1408	0.1434	0.1408
822	QF 38-65	-0.5763	NA	-0.5093	-0.5223	-0.5709	-0.5657	-0.5700
823	QF 64-65	-0.6649	-0.6705	-0.6375	-0.6705	-0.6695	-0.6699	-0.6705
824	QF 49-66	0.0433	NA	0.0249	0.0543	0.0427	0.0446	0.0424
825	QF 49-66	0.0433	NA	0.0249	0.0543	0.0427	0.0446	0.0424
826	QF 62-66	-0.1726	NA	-0.1670	-0.1755	-0.1736	-0.1746	-0.1732
827	QF 62-67	-0.1441	-0.1480	-0.1405	-0.1497	-0.1470	-0.1480	-0.1480
828	QF 65-66	0.7225	NA	0.7586	0.7145	0.7304	0.7216	0.7297
829	QF 66-67	0.1927	NA	0.1841	0.1953	0.1933	0.1940	0.1911
830	QF 65-68	-0.2243	-0.2251	-0.2298	-0.2969	-0.2261	-0.2384	-0.2251
831	QF 47-69	0.1163	0.1167	0.1070	0.1149	0.1142	0.1135	0.1138
832	QF 49-69	0.1065	NA	0.0970	0.1029	0.1037	0.1033	0.1034
833	QF 68-69	1.1282	NA	1.1143	1.0919	1.1157	1.1044	1.1111
834	QF 69-70	0.1607	NA	0.1351	0.1439	0.1632	0.1582	0.1650
835	QF 24-70	-0.0297	NA	-0.0060	-0.0247	-0.0301	-0.0287	-0.0303
836	QF 70-71	-0.1238	NA	-0.1744	-0.1774	-0.1261	-0.1364	-0.1238
837	QF 24-72	0.0331	NA	0.0379	0.0303	0.0316	0.0306	0.0321
838	QF 71-72	-0.0094	-0.0094	-0.0527	-0.0146	-0.0104	-0.0141	-0.0097
839	QF 71-73	-0.1074	-0.1068	-0.1152	-0.1563	-0.1078	-0.1155	-0.1068
840	QF 70-74	0.1289	NA	0.1545	0.1502	0.1318	0.1348	0.1307
841	QF 70-75	0.0994	NA	0.1262	0.1198	0.1022	0.1054	0.1015
842	QF 69-75	0.2049	0.2124	0.2094	0.2124	0.2114	0.2097	0.2124
843	QF 74-75	-0.0619	-0.0604	-0.0531	-0.0604	-0.0614	-0.0604	-0.0604
844	QF 76-77	-0.2104	-0.2104	-0.2170	-0.2289	-0.2181	-0.2177	-0.2192
845	QF 69-77	0.0678	NA	0.0657	0.0510	0.0671	0.0662	0.0671
846	QF 75-77	-0.0955	NA	-0.0987	-0.1072	-0.0996	-0.0988	-0.1002

847	QF 77-78	0.0661	NA	0.0332	0.0105	0.0378	0.0369	0.0420
848	QF 78-79	-0.1837	-0.1824	-0.1816	-0.1824	-0.1814	-0.1806	-0.1824
849	QF 77-80	-0.3741	NA	-0.3687	-0.3782	-0.3680	-0.3663	-0.3707
850	QF 77-80	-0.2055	NA	-0.2032	-0.2076	-0.2028	-0.2020	-0.2041
851	QF 79-80	-0.2958	NA	-0.2878	-0.2901	-0.2878	-0.2868	-0.2903
852	QF 68-81	-0.0461	NA	-0.0586	-0.1044	-0.0530	-0.0599	-0.0481
853	QF 81-80	0.7554	0.7379	0.7448	0.6970	0.7498	0.7423	0.7379
854	QF 77-82	0.1755	0.1758	0.1829	0.1832	0.1768	0.1759	0.1758
855	QF 82-83	0.2439	NA	0.2520	0.2447	0.2447	0.2487	0.2437
856	QF 83-84	0.1469	NA	0.1551	0.1490	0.1500	0.1490	0.1487
857	QF 83-85	0.1200	NA	0.1271	0.1215	0.1218	0.1218	0.1211
858	QF 84-85	0.0899	0.0895	0.0883	0.0895	0.0885	0.0895	0.0895
859	QF 85-86	-0.0735	NA	-0.0730	-0.0714	-0.0734	-0.0724	-0.0724
860	QF 86-87	-0.1509	-0.1557	-0.1523	-0.1520	-0.1530	-0.1520	-0.1521
861	QF 85-88	0.0760	0.0731	0.0767	0.0731	0.0743	0.0732	0.0737
862	QF 85-89	0.0068	NA	0.0060	0.0056	0.0063	0.0053	0.0059
863	QF 88-89	-0.0247	NA	-0.0274	-0.0229	-0.0232	-0.0239	-0.0231
864	QF 89-90	-0.0472	NA	-0.0482	-0.0482	-0.0474	-0.0472	-0.0471
865	QF 89-90	-0.0544	NA	-0.0560	-0.0562	-0.0546	-0.0542	-0.0539
866	QF 90-91	0.0442	NA	0.0397	0.0435	0.0462	0.0454	0.0466
867	QF 89-92	-0.0210	NA	-0.0249	-0.0174	-0.0207	-0.0211	-0.0201
868	QF 89-92	-0.0507	NA	-0.0519	-0.0494	-0.0507	-0.0507	-0.0504
869	QF 91-92	-0.0663	-0.0663	-0.0628	-0.0624	-0.0673	-0.0663	-0.0673
870	QF 92-93	-0.1166	-0.1143	-0.1090	-0.1143	-0.1133	-0.1143	-0.1143
871	QF 92-94	-0.1521	NA	-0.1598	-0.1562	-0.1540	-0.1531	-0.1529
872	QF 93-94	-0.1950	NA	-0.2202	-0.2065	-0.2035	-0.1997	-0.1994
873	QF 94-95	0.0901	0.0934	0.0945	0.0934	0.0944	0.0934	0.0934
874	QF 80-96	0.2107	NA	0.2124	0.2143	0.2096	0.2097	0.2104
875	QF 82-96	-0.0657	-0.0648	-0.0680	-0.0714	-0.0658	-0.0628	-0.0648
876	QF 94-96	-0.0982	NA	-0.0973	-0.0979	-0.0968	-0.0979	-0.0977
877	QF 80-97	0.2575	NA	0.2598	0.2627	0.2576	0.2581	0.2588
878	QF 80-98	0.0832	NA	0.0858	0.0827	0.0852	0.0843	0.0868
879	QF 80-99	0.0817	NA	0.0825	0.0775	0.0810	0.0799	0.0817
880	QF 92-100	-0.1653	-0.1713	-0.1684	-0.1713	-0.1640	-0.1649	-0.1634
881	QF 94-100	-0.5054	NA	-0.5007	-0.5252	-0.4954	-0.5013	-0.4944
882	QF 95-96	-0.2169	-0.2188	-0.2188	-0.2188	-0.2178	-0.2188	-0.2185
883	QF 96-97	-0.2016	NA	-0.2028	-0.2035	-0.1998	-0.1992	-0.1999
884	QF 98-100	0.0243	0.0238	0.0256	0.0212	0.0248	0.0239	0.0253
885	QF 99-100	-0.0459	-0.0467	-0.0417	-0.0429	-0.0405	-0.0407	-0.0389
886	QF 100-101	0.2290	0.2323	0.2418	0.2838	0.2313	0.2308	0.2323
887	QF 92-102	-0.0839	NA	-0.0780	-0.0551	-0.0795	-0.0799	-0.0782

888	QF 101-102	0.1013	0.1027	0.0985	0.0713	0.0979	0.1001	0.0950
889	QF 100-103	-0.2215	NA	-0.2205	-0.2162	-0.2170	-0.2208	-0.2158
890	QF 100-104	0.1065	NA	0.1044	0.1093	0.1057	0.1053	0.1066
891	QF 103-104	0.1387	NA	0.1367	0.1411	0.1369	0.1376	0.1376
892	QF 103-105	0.1285	NA	0.1268	0.1325	0.1270	0.1274	0.1275
893	QF 100-106	0.0948	0.0913	0.0920	0.0982	0.0934	0.0927	0.0933
894	QF 104-105	0.0263	NA	0.0271	0.0337	0.0272	0.0262	0.0262
895	QF 105-105	0.0388	NA	0.0349	0.0378	0.0357	0.0348	0.0326
896	QF 105-107	-0.0237	NA	-0.0245	-0.0179	-0.0256	-0.0247	-0.0254
897	QF 105-108	-0.1113	-0.1074	-0.1064	-0.1074	-0.1084	-0.1074	-0.1074
898	QF 106-107	-0.0373	NA	-0.0369	-0.0312	-0.0382	-0.0371	-0.0371
899	QF 108-109	-0.1092	-0.1134	-0.1112	-0.1108	-0.1118	-0.1134	-0.1134
900	QF 103-110	0.0835	NA	0.0835	0.0936	0.0809	0.0828	0.0805
901	QF 109-110	-0.1339	-0.1392	-0.1334	-0.1224	-0.1382	-0.1350	-0.1398
902	QF 110-111	0.0096	NA	0.0120	0.0398	0.0105	0.0095	0.0095
903	QF 110-112	-0.3061	NA	-0.2952	-0.3032	-0.3024	-0.2965	-0.3034
904	QF 17-113	0.0590	0.0566	0.0631	0.0566	0.0556	0.0566	0.0566
905	QF 32-113	-0.1780	NA	-0.1706	-0.1651	-0.1749	-0.1640	-0.1757
906	QF 32-114	0.0178	NA	0.0313	0.0176	0.0187	0.0177	0.0177
907	QF 27-115	0.0506	0.0516	0.0417	0.0516	0.0506	0.0490	0.0516
908	QF 114-115	0.0022	0.0021	0.0035	0.0021	0.0031	0.0021	0.0021
909	QF 68-116	-0.6636	NA	-0.6415	-0.6436	-0.6454	-0.6400	-0.6443
910	QF 12-117	0.0520	0.0529	0.0570	0.0529	0.0527	0.0529	0.0529
911	QF 75-118	0.2359	0.2421	0.2416	0.2432	0.2411	0.2421	0.2421
912	QF 76-118	-0.0969	-0.0995	-0.0985	-0.0995	-0.0985	-0.0995	-0.0987
913	QT 1-2	0.1101	NA	0.0438	0.1065	0.1073	0.1064	0.1062

914	QT 1-3	0.1688	NA	0.1147	0.1688	0.1712	0.1717	0.1684
915	QT 4-5	0.2749	NA	0.2983	0.2793	0.2786	0.2784	0.2775
916	QT 3-5	0.1728	NA	0.1050	0.1757	0.1762	0.1770	0.1759
917	QT 5-6	-0.0130	NA	0.0146	-0.0187	-0.0155	-0.0174	-0.0184
918	QT 6-7	0.0451	NA	0.0489	0.0468	0.0457	0.0467	0.0467
919	QT 8-9	0.2443	NA	0.2701	0.3276	0.2463	0.2547	0.2447
920	QT 8-5	-0.9201	NA	-1.0268	-1.0263	-0.9229	-0.9463	-0.9153
921	QT 9-10	-0.5104	NA	-0.5109	-0.4485	-0.5226	-0.5074	-0.5224
922	QT 4-11	0.0135	NA	0.0066	0.0143	0.0148	0.0141	0.0138
923	QT 5-11	-0.0062	NA	-0.0198	-0.0059	-0.0051	-0.0059	-0.0062
924	QT 11-12	0.3513	0.3379	0.3751	0.3379	0.3397	0.3419	0.3399
925	QT 2-12	0.1942	NA	0.1902	0.2013	0.2060	0.2070	0.2025
926	QT 3-12	0.0886	NA	0.0594	0.0891	0.0906	0.0904	0.0894
927	QT 7-12	0.0576	NA	0.0491	0.0590	0.0593	0.0589	0.0589
928	QT 11-13	-0.1216	-0.1259	0.0341	-0.0717	-0.1274	-0.1250	-0.1239
929	QT 12-14	-0.0414	NA	-0.0722	-0.0805	-0.0492	-0.0492	-0.0574
930	QT 13-15	-0.0204	-0.0202	-0.0537	-0.0234	-0.0236	-0.0202	-0.0267
931	QT 14-15	-0.0783	NA	-0.0529	-0.0481	-0.0803	-0.0756	-0.0801
932	QT 12-16	-0.0632	NA	-0.0601	-0.0527	-0.0691	-0.0689	-0.0727
933	QT 15-17	0.2522	0.2547	0.2512	0.2547	0.2452	0.2446	0.2431
934	QT 16-17	-0.0030	NA	0.0065	0.0111	-0.0107	-0.0021	-0.0092
935	QT 17-18	-0.2240	NA	-0.2276	-0.2165	-0.2174	-0.2163	-0.2164
936	QT 18-19	-0.1755	-0.1723	-0.1770	-0.1772	-0.1776	-0.1722	-0.1764
937	QT 19-20	-0.0771	NA	-0.0719	-0.0739	-0.0740	-0.0635	-0.0740
938	QT 15-19	-0.1650	NA	-0.1693	-0.1548	-0.1668	-0.1594	-0.1663
939	QT 20-21	-0.0590	-0.0578	-0.0551	-0.0557	-0.0568	-0.0498	-0.0578
940	QT 21-22	0.0176	0.0179	0.0253	0.0185	0.0179	0.0179	0.0184
941	QT 22-23	0.0769	0.0749	0.1017	0.0876	0.0759	0.0749	0.0749
942	QT 23-24	-0.1524	NA	-0.1548	-0.1545	-0.1533	-0.1544	-0.1542
943	QT 23-25	0.3863	0.3793	0.3789	0.3793	0.3983	0.3914	0.3985
944	QT 26-25	-0.1864	-0.1919	-0.1925	-0.1596	-0.1909	-0.1782	-0.1919
945	QT 25-27	-0.1525	NA	-0.1885	-0.1464	-0.1548	-0.1527	-0.1549
946	QT 27-28	-0.0043	-0.0044	-0.0128	-0.0155	-0.0054	-0.0095	-0.0044
947	QT 28-29	0.0464	NA	0.0504	0.0445	0.0436	0.0445	0.0446
948	QT 30-17	-0.7010	NA	-0.7140	-0.7148	-0.7272	-0.7323	-0.7299
949	QT 8-30	-0.7542	-0.7834	-0.7159	-0.7361	-0.7694	-0.7517	-0.7716
950	QT 26-30	-0.3657	NA	-0.4328	-0.3756	-0.3734	-0.3854	-0.3709
951	QT 17-31	-0.1473	NA	-0.1468	-0.1360	-0.1447	-0.1334	-0.1442
952	QT 29-31	0.0792	0.0803	0.0895	0.0803	0.0812	0.0761	0.0803
953	QT 23-32	-0.0624	NA	-0.1001	-0.0621	-0.0622	-0.0627	-0.0637
954	QT 31-32	-0.1360	NA	-0.1223	-0.1262	-0.1325	-0.1278	-0.1353
955	QT 27-32	-0.0343	NA	-0.0150	-0.0351	-0.0333	-0.0325	-0.0351

956	QT 15-33	0.0149	NA	0.0198	0.0353	0.0222	0.0252	0.0212
957	QT 19-34	0.0460	0.0452	0.0495	0.0665	0.0530	0.0562	0.0537
958	QT 35-36	-0.0429	NA	-0.0498	-0.0400	-0.0423	-0.0398	-0.0418
959	QT 35-37	0.1243	0.1219	0.1311	0.1219	0.1235	0.1219	0.1219
960	QT 33-37	0.0746	0.0768	0.0791	0.0933	0.0791	0.0832	0.0811
961	QT 34-36	-0.0498	NA	-0.0470	-0.0559	-0.0526	-0.0538	-0.0516
962	QT 34-37	0.4429	NA	0.4958	0.4119	0.4313	0.4175	0.4261
963	QT 38-37	-0.8801	NA	-0.8434	-0.8041	-0.8700	-0.8589	-0.8679
964	QT 37-39	-0.0230	NA	-0.0702	-0.0429	-0.0252	-0.0235	-0.0238
965	QT 37-40	0.0296	NA	0.0015	0.0176	0.0284	0.0301	0.0298
966	QT 30-38	-0.5598	-0.5403	-0.5946	-0.5403	-0.5552	-0.5489	-0.5549
967	QT 39-40	0.0775	NA	0.0803	0.0803	0.0794	0.0804	0.0804
968	QT 40-41	-0.0221	NA	-0.0273	-0.0219	-0.0228	-0.0219	-0.0219
969	QT 40-42	0.0230	0.0221	0.0106	0.0131	0.0211	0.0197	0.0208
970	QT 41-42	0.0524	0.0527	0.0375	0.0389	0.0501	0.0479	0.0493
971	QT 43-44	-0.0379	NA	-0.0617	-0.0365	-0.0389	-0.0410	-0.0395
972	QT 34-43	-0.0567	NA	-0.0756	-0.1459	-0.0584	-0.0665	-0.0574
973	QT 44-45	-0.0662	NA	-0.0885	0.0677	-0.0687	-0.0619	-0.0703
974	QT 45-46	0.0212	NA	0.0189	-0.0001	0.0167	0.0217	0.0162
975	QT 46-47	-0.0079	-0.0080	-0.0047	-0.0175	-0.0090	-0.0084	-0.0092
976	QT 46-48	0.0142	NA	0.0111	0.0042	0.0122	0.0142	0.0119
977	QT 47-49	0.0928	NA	0.0868	0.0818	0.0886	0.0895	0.0886
978	QT 42-49	0.0037	0.0037	-0.0091	-0.0088	-0.0006	-0.0013	-0.0011
979	QT 42-49	0.0037	0.0038	-0.0091	-0.0088	-0.0006	-0.0013	-0.0011
980	QT 45-49	0.0231	NA	0.0217	-0.0021	0.0178	0.0222	0.0173
981	QT 48-49	-0.0393	-0.0388	-0.0276	-0.0388	-0.0398	-0.0443	-0.0388
982	QT 49-50	-0.1314	-0.1303	-0.1803	-0.1303	-0.1293	-0.1303	-0.1303
983	QT 49-51	-0.1740	-0.1775	-0.1684	-0.1775	-0.1707	-0.1676	-0.1711
984	QT 51-52	-0.0699	-0.0721	-0.0783	-0.0748	-0.0697	-0.0721	-0.0704
985	QT 52-53	-0.0545	NA	-0.0610	-0.0603	-0.0546	-0.0580	-0.0544
986	QT 53-54	0.0299	NA	0.0358	0.0387	0.0291	0.0279	0.0298
987	QT 49-54	-0.1560	-0.1577	-0.1551	-0.1586	-0.1552	-0.1566	-0.1550
988	QT 49-54	-0.1379	NA	-0.1393	-0.1403	-0.1371	-0.1384	-0.1368
989	QT 54-55	-0.0325	NA	-0.0320	-0.0325	-0.0327	-0.0329	-0.0325
990	QT 54-56	-0.0498	-0.0496	-0.0580	-0.0496	-0.0506	-0.0530	-0.0496
991	QT 55-56	0.0557	0.0538	0.0480	0.0555	0.0554	0.0549	0.0555
992	QT 56-57	0.0749	NA	0.0347	0.0452	0.0784	0.0741	0.0774
993	QT 50-57	-0.1049	NA	-0.1136	-0.1328	-0.1014	-0.1074	-0.1010
994	QT 56-58	0.0153	0.0153	0.0244	0.0182	0.0163	0.0227	0.0160
995	QT 51-58	-0.0453	NA	-0.0508	-0.0449	-0.0461	-0.0494	-0.0451
996	QT 54-59	0.0426	0.0432	0.0491	0.0432	0.0421	0.0432	0.0412
997	QT 56-59	0.0099	NA	0.0201	0.0107	0.0093	0.0106	0.0086

998	QT 56-59	0.0113	0.0113	0.0223	0.0122	0.0107	0.0120	0.0099
999	QT 55-59	0.0588	NA	0.0652	0.0595	0.0584	0.0596	0.0574
1000	QT 59-60	-0.0440	NA	-0.0541	-0.0446	-0.0434	-0.0444	-0.0431
1001	QT 59-61	-0.0463	-0.0476	-0.0559	-0.0468	-0.0457	-0.0464	-0.0451
1002	QT 60-61	-0.0823	-0.0831	-0.0796	-0.0831	-0.0821	-0.0798	-0.0779
1003	QT 60-62	0.0574	NA	0.0470	0.0462	0.0508	0.0501	0.0544
1004	QT 61-62	0.1320	NA	0.1155	0.1155	0.1220	0.1202	0.1258
1005	QT 63-59	-0.5702	-0.5856	-0.5484	-0.5664	-0.5736	-0.5702	-0.5746
1006	QT 63-64	0.5251	0.5083	0.4975	0.5264	0.5277	0.5265	0.5293
1007	QT 64-61	-0.1368	NA	-0.1368	-0.1408	-0.1377	-0.1401	-0.1378
1008	QT 38-65	-0.0837	NA	-0.1425	-0.1315	-0.0915	-0.0957	-0.0912
1009	QT 64-65	0.4006	NA	0.3708	0.4126	0.4068	0.4082	0.4077
1010	QT 49-66	0.0832	0.0853	0.1077	0.0743	0.0848	0.0829	0.0853
1011	QT 49-66	0.0832	NA	0.1077	0.0743	0.0848	0.0829	0.0853
1012	QT 62-66	0.1468	0.1514	0.1405	0.1514	0.1487	0.1500	0.1481
1013	QT 62-67	0.1215	NA	0.1175	0.1273	0.1242	0.1258	0.1252
1014	QT 65-66	-0.7055	-0.6965	-0.7399	-0.6978	-0.7131	-0.7047	-0.7124
1015	QT 66-67	-0.1915	-0.1917	-0.1831	-0.1917	-0.1904	-0.1917	-0.1883
1016	QT 65-68	-0.4185	NA	-0.4142	-0.3439	-0.4184	-0.4045	-0.4190
1017	QT 47-69	-0.1007	NA	-0.0883	-0.0981	-0.0987	-0.0978	-0.0981
1018	QT 49-69	-0.1206	-0.1240	-0.1092	-0.1163	-0.1182	-0.1177	-0.1177
1019	QT 68-69	-1.0364	-1.0038	-1.0249	-1.0038	-1.0264	-1.0153	-1.0219
1020	QT 69-70	-0.1398	NA	-0.1136	-0.1239	-0.1437	-0.1379	-0.1454
1021	QT 24-70	-0.0680	-0.0701	-0.0924	-0.0735	-0.0680	-0.0692	-0.0676
1022	QT 70-71	0.1168	NA	0.1680	0.1710	0.1191	0.1296	0.1168
1023	QT 24-72	-0.0798	-0.0776	-0.0860	-0.0776	-0.0786	-0.0776	-0.0790
1024	QT 71-72	-0.0315	NA	0.0115	-0.0265	-0.0306	-0.0268	-0.0313
1025	QT 71-73	0.0965	NA	0.1043	0.1459	0.0969	0.1047	0.0959
1026	QT 70-74	-0.1542	-0.1599	-0.1790	-0.1745	-0.1570	-0.1599	-0.1559
1027	QT 70-75	-0.1317	NA	-0.1576	-0.1514	-0.1345	-0.1375	-0.1337
1028	QT 69-75	-0.1831	NA	-0.1869	-0.1897	-0.1898	-0.1876	-0.1906
1029	QT 74-75	0.0644	NA	0.0553	0.0627	0.0636	0.0626	0.0626
1030	QT 76-77	0.2439	NA	0.2517	0.2651	0.2522	0.2521	0.2534
1031	QT 69-77	-0.1380	-0.1372	-0.1369	-0.1225	-0.1382	-0.1372	-0.1381
1032	QT 75-77	0.0738	0.0760	0.0775	0.0865	0.0781	0.0775	0.0787
1033	QT 77-78	-0.0763	NA	-0.0433	-0.0207	-0.0479	-0.0470	-0.0521
1034	QT 78-79	0.1795	NA	0.1774	0.1782	0.1772	0.1764	0.1782
1035	QT 77-80	0.3753	NA	0.3703	0.3800	0.3692	0.3676	0.3721
1036	QT 77-80	0.2059	NA	0.2039	0.2084	0.2032	0.2025	0.2046
1037	QT 79-80	0.3108	0.2989	0.3031	0.3053	0.3030	0.3020	0.3055
1038	QT 68-81	-0.7554	NA	-0.7448	-0.6970	-0.7508	-0.7423	-0.7551
1039	QT 81-80	-0.7305	NA	-0.7202	-0.6748	-0.7251	-0.7178	-0.7138

1040	QT 77-82	-0.2528	NA	-0.2602	-0.2604	-0.2543	-0.2534	-0.2534
1041	QT 82-83	-0.2699	-0.2697	-0.2778	-0.2706	-0.2707	-0.2746	-0.2697
1042	QT 83-84	-0.1599	NA	-0.1679	-0.1615	-0.1629	-0.1620	-0.1614
1043	QT 83-85	-0.1229	NA	-0.1297	-0.1244	-0.1243	-0.1247	-0.1239
1044	QT 84-85	-0.0924	NA	-0.0908	-0.0927	-0.0909	-0.0921	-0.0923
1045	QT 85-86	0.0509	0.0497	0.0504	0.0487	0.0507	0.0497	0.0497
1046	QT 86-87	0.1102	0.1112	0.1117	0.1112	0.1122	0.1112	0.1112
1047	QT 85-88	-0.0753	NA	-0.0765	-0.0736	-0.0735	-0.0731	-0.0737
1048	QT 85-89	0.0373	NA	0.0379	0.0372	0.0382	0.0383	0.0375
1049	QT 88-89	0.0770	0.0756	0.0804	0.0756	0.0758	0.0765	0.0756
1050	QT 89-90	0.0581	NA	0.0596	0.0591	0.0586	0.0585	0.0581
1051	QT 89-90	0.0707	0.0725	0.0734	0.0725	0.0713	0.0712	0.0704
1052	QT 90-91	-0.0646	NA	-0.0602	-0.0640	-0.0667	-0.0658	-0.0671
1053	QT 89-92	0.1696	NA	0.1730	0.1637	0.1696	0.1683	0.1673
1054	QT 89-92	0.0729	NA	0.0740	0.0709	0.0730	0.0724	0.0721
1055	QT 91-92	0.0359	NA	0.0323	0.0318	0.0368	0.0359	0.0368
1056	QT 92-93	0.1250	NA	0.1171	0.1223	0.1212	0.1223	0.1222
1057	QT 92-94	0.1591	0.1633	0.1672	0.1633	0.1619	0.1601	0.1600
1058	QT 93-94	0.1944	NA	0.2206	0.2065	0.2042	0.1996	0.1995
1059	QT 94-95	-0.0931	NA	-0.0974	-0.0962	-0.0973	-0.0962	-0.0963
1060	QT 80-96	-0.2462	NA	-0.2479	-0.2496	-0.2454	-0.2454	-0.2460
1061	QT 82-96	0.0129	NA	0.0151	0.0186	0.0129	0.0100	0.0119
1062	QT 94-96	0.0798	0.0799	0.0788	0.0794	0.0782	0.0794	0.0791
1063	QT 80-97	-0.2719	NA	-0.2741	-0.2769	-0.2720	-0.2725	-0.2732
1064	QT 80-98	-0.1043	-0.1038	-0.1069	-0.1037	-0.1063	-0.1055	-0.1078
1065	QT 80-99	-0.1294	NA	-0.1303	-0.1255	-0.1289	-0.1277	-0.1295
1066	QT 92-100	0.1537	NA	0.1572	0.1603	0.1528	0.1533	0.1517
1067	QT 94-100	0.4581	0.4462	0.4529	0.4787	0.4472	0.4536	0.4462
1068	QT 95-96	0.2051	NA	0.2070	0.2070	0.2059	0.2070	0.2067
1069	QT 96-97	0.1819	0.1884	0.1830	0.1838	0.1799	0.1794	0.1800
1070	QT 98-100	-0.0730	NA	-0.0744	-0.0702	-0.0736	-0.0727	-0.0741
1071	QT 99-100	0.0279	NA	0.0236	0.0248	0.0224	0.0227	0.0209
1072	QT 100-101	-0.2513	NA	-0.2633	-0.3024	-0.2535	-0.2529	-0.2544
1073	QT 92-102	0.0813	NA	0.0753	0.0521	0.0769	0.0772	0.0755
1074	QT 101-102	-0.1113	NA	-0.1086	-0.0819	-0.1077	-0.1103	-0.1053
1075	QT 100-103	0.2436	0.2370	0.2416	0.2370	0.2380	0.2421	0.2370
1076	QT 100-104	-0.0941	NA	-0.0935	-0.0981	-0.0946	-0.0940	-0.0953

1077	QT 103-104	-0.1583	NA	-0.1570	-0.1611	-0.1571	-0.1577	-0.1577
1078	QT 103-105	-0.1348	NA	-0.1340	-0.1393	-0.1340	-0.1343	-0.1343
1079	QT 100-106	-0.0712	NA	-0.0704	-0.0759	-0.0713	-0.0704	-0.0710
1080	QT 104-105	-0.0261	-0.0260	-0.0269	-0.0335	-0.0270	-0.0260	-0.0260
1081	QT 105-105	-0.0515	-0.0506	-0.0477	-0.0506	-0.0485	-0.0476	-0.0454
1082	QT 105-107	-0.0055	NA	-0.0050	-0.0114	-0.0039	-0.0046	-0.0040
1083	QT 105-108	0.0992	NA	0.0942	0.0952	0.0963	0.0952	0.0952
1084	QT 106-107	0.0055	0.0053	0.0050	-0.0006	0.0063	0.0053	0.0053
1085	QT 108-109	0.1039	0.1055	0.1059	0.1055	0.1065	0.1081	0.1081
1086	QT 103-110	-0.0615	NA	-0.0625	-0.0721	-0.0596	-0.0614	-0.0593
1087	QT 109-110	0.1177	NA	0.1172	0.1060	0.1221	0.1189	0.1237
1088	QT 110-111	-0.0184	NA	-0.0211	-0.0487	-0.0196	-0.0186	-0.0186
1089	QT 110-112	0.2851	NA	0.2728	0.2812	0.2802	0.2742	0.2812
1090	QT 17-113	-0.0665	NA	-0.0707	-0.0641	-0.0631	-0.0641	-0.0641
1091	QT 32-113	0.1340	0.1336	0.1249	0.1198	0.1306	0.1188	0.1314
1092	QT 32-114	-0.0322	-0.0322	-0.0460	-0.0322	-0.0332	-0.0322	-0.0322
1093	QT 27-115	-0.0653	NA	-0.0567	-0.0663	-0.0652	-0.0636	-0.0662
1094	QT 114-115	-0.0047	NA	-0.0061	-0.0047	-0.0057	-0.0047	-0.0047
1095	QT 68-116	0.5132	0.4934	0.4907	0.4934	0.4944	0.4895	0.4934
1096	QT 12-117	-0.0800	#N/A	-0.0867	-0.0808	-0.0810	-0.0809	-0.0812
1097	QT 75-118	-0.2356	#N/A	-0.2413	-0.2426	-0.2407	-0.2417	-0.2417
1098	QT 76-118	0.0856	#N/A	0.0871	0.0882	0.0871	0.0882	0.0873

B.3.4 Presence of a Multiple Interacting Bad-data

Table B.13 IEEE 118 Bus System with five multiple interacting bad-data in SCADA measurements

Sr	*Type*	*Actual*	*Measurement*	*Estimated*				

				WLS	*WLAV*	*LMR*	*HLMR*	*ULMR*
1	Vm-1	0.9550	NA	0.9624	0.9555	0.9561	0.9543	0.9571
2	Vm-2	0.9714	0.9687	0.9789	0.9714	0.9722	0.9703	0.9731
3	Vm-3	0.9677	0.9694	0.9747	0.9684	0.9690	0.9672	0.9698
4	Vm-4	0.9980	1.0388	1.0021	0.9991	0.9997	0.9978	1.0004
5	Vm-5	1.0020	1.0445	1.0059	1.0032	1.0037	1.0018	1.0044
6	Vm-6	0.9900	NA	0.9987	0.9908	0.9917	0.9898	0.9922
7	Vm-7	0.9893	NA	0.9985	0.9901	0.9910	0.9891	0.9916
8	Vm-8	1.0150	NA	1.0213	1.0164	1.0167	1.0155	1.0172
9	Vm-9	1.0429	1.0963	1.0509	1.0445	1.0448	1.0437	1.0452
10	Vm-10	1.0500	NA	1.0591	1.0515	1.0517	1.0510	1.0520
11	Vm-11	0.9851	NA	0.9959	0.9861	0.9869	0.9850	0.9877
12	Vm-12	0.9900	0.9828	1.0003	0.9907	0.9917	0.9899	0.9923
13	Vm-13	0.9683	NA	0.9900	0.9689	0.9697	0.9680	0.9708
14	Vm-14	0.9836	NA	1.0020	0.9827	0.9852	0.9836	0.9848
15	Vm-15	0.9700	0.9703	0.9794	0.9702	0.9713	0.9698	0.9709
16	Vm-16	0.9839	NA	0.9929	0.9842	0.9850	0.9833	0.9855
17	Vm-17	0.9951	1.0000	1.0032	0.9951	0.9955	0.9945	0.9956
18	Vm-18	0.9730	0.9768	0.9808	0.9734	0.9737	0.9728	0.9739
19	Vm-19	0.9620	NA	0.9697	0.9624	0.9630	0.9619	0.9628
20	Vm-20	0.9569	NA	0.9625	0.9587	0.9584	0.9583	0.9583
21	Vm-21	0.9577	0.9604	0.9625	0.9601	0.9594	0.9598	0.9592
22	Vm-22	0.9690	NA	0.9739	0.9715	0.9706	0.9711	0.9707
23	Vm-23	0.9995	1.0001	1.0049	1.0016	1.0004	1.0010	1.0006
24	Vm-24	0.9920	0.9873	0.9969	0.9939	0.9929	0.9936	0.9931
25	Vm-25	1.0500	1.0536	1.0563	1.0523	1.0520	1.0521	1.0522
26	Vm-26	1.0150	NA	1.0211	1.0169	1.0170	1.0167	1.0173
27	Vm-27	0.9680	0.9732	0.9738	0.9703	0.9688	0.9698	0.9691
28	Vm-28	0.9616	0.9598	0.9672	0.9635	0.9623	0.9629	0.9626
29	Vm-29	0.9632	0.9696	0.9696	0.9650	0.9638	0.9645	0.9641
30	Vm-30	0.9853	0.9891	0.9925	0.9865	0.9866	0.9859	0.9868
31	Vm-31	0.9670	NA	0.9736	0.9687	0.9677	0.9681	0.9679
32	Vm-32	0.9630	NA	0.9690	0.9652	0.9639	0.9647	0.9640
33	Vm-33	0.9709	NA	0.9791	0.9724	0.9825	0.9719	0.9727
34	Vm-34	0.9840	0.9922	0.9917	0.9868	0.9868	0.9862	0.9866
35	Vm-35	0.9805	NA	0.9884	0.9832	0.9833	0.9827	0.9830
36	Vm-36	0.9800	0.9866	0.9879	0.9828	0.9828	0.9822	0.9826
37	Vm-37	0.9907	0.9967	0.9988	0.9933	0.9934	0.9927	0.9931
38	Vm-38	0.9613	NA	0.9676	0.9629	0.9633	0.9625	0.9631
39	Vm-39	0.9700	NA	0.9747	0.9721	0.9730	0.9723	0.9727
40	Vm-40	0.9700	0.9747	0.9749	0.9723	0.9731	0.9725	0.9728
41	Vm-41	0.9668	NA	0.9715	0.9690	0.9699	0.9693	0.9697

42	Vm-42	0.9850	0.9796	0.9884	0.9864	0.9875	0.9866	0.9872
43	Vm-43	0.9771	NA	0.9822	0.9782	0.9797	0.9777	0.9796
44	Vm-44	0.9844	0.9748	0.9860	0.9846	0.9868	0.9844	0.9866
45	Vm-45	0.9864	0.9905	0.9873	0.9868	0.9883	0.9868	0.9881
46	Vm-46	1.0050	1.0054	1.0059	1.0053	1.0063	1.0054	1.0060
47	Vm-47	1.0171	NA	1.0179	1.0173	1.0182	1.0173	1.0179
48	Vm-48	1.0206	NA	1.0215	1.0209	1.0215	1.0210	1.0213
49	Vm-49	1.0250	1.0334	1.0257	1.0250	1.0259	1.0251	1.0257
50	Vm-50	1.0011	NA	1.0019	1.0014	1.0024	1.0015	1.0020
51	Vm-51	0.9669	0.9762	0.9677	0.9673	0.9679	0.9675	0.9678
52	Vm-52	0.9568	NA	0.9573	0.9570	0.9578	0.9573	0.9576
53	Vm-53	0.9460	0.9407	0.9457	0.9454	0.9470	0.9458	0.9468
54	Vm-54	0.9550	0.9515	0.9549	0.9545	0.9559	0.9546	0.9559
55	Vm-55	0.9520	NA	0.9519	0.9514	0.9529	0.9516	0.9528
56	Vm-56	0.9540	0.9511	0.9539	0.9535	0.9549	0.9536	0.9549
57	Vm-57	0.9706	0.9646	0.9703	0.9699	0.9718	0.9701	0.9716
58	Vm-58	0.9590	NA	0.9595	0.9591	0.9600	0.9594	0.9599
59	Vm-59	0.9850	0.9915	0.9855	0.9849	0.9858	0.9848	0.9856
60	Vm-60	0.9932	NA	0.9935	0.9929	0.9941	0.9929	0.9939
61	Vm-61	0.9950	NA	0.9953	0.9948	0.9959	0.9947	0.9958
62	Vm-62	0.9980	0.9923	0.9979	0.9974	0.9983	0.9972	0.9984
63	Vm-63	0.9687	0.9648	0.9692	0.9686	0.9696	0.9685	0.9694
64	Vm-64	0.9837	0.9782	0.9842	0.9836	0.9846	0.9836	0.9845
65	Vm-65	1.0050	NA	1.0056	1.0051	1.0061	1.0051	1.0060
66	Vm-66	1.0500	NA	1.0507	1.0501	1.0510	1.0501	1.0509
67	Vm-67	1.0197	NA	1.0204	1.0198	1.0204	1.0195	1.0204
68	Vm-68	1.0032	0.9981	1.0041	1.0035	1.0044	1.0035	1.0043
69	Vm-69	1.0350	1.0435	1.0367	1.0361	1.0367	1.0361	1.0367
70	Vm-70	0.9840	0.9887	0.9861	0.9852	0.9853	0.9854	0.9852
71	Vm-71	0.9868	0.9886	0.9895	0.9885	0.9882	0.9886	0.9881
72	Vm-72	0.9800	NA	0.9844	0.9824	0.9815	0.9821	0.9813
73	Vm-73	0.9910	0.9973	0.9940	0.9930	0.9924	0.9932	0.9922
74	Vm-74	0.9580	NA	0.9586	0.9580	0.9590	0.9587	0.9590
75	Vm-75	0.9673	0.9578	0.9677	0.9671	0.9682	0.9678	0.9681
76	Vm-76	0.9430	0.9415	0.9432	0.9427	0.9436	0.9431	0.9435
77	Vm-77	1.0060	1.0122	1.0077	1.0073	1.0078	1.0074	1.0079
78	Vm-78	1.0034	NA	1.0055	1.0051	1.0055	1.0051	1.0055
79	Vm-79	1.0092	NA	1.0113	1.0108	1.0113	1.0108	1.0113
80	Vm-80	1.0400	1.0495	1.0416	1.0411	1.0416	1.0411	1.0418
81	Vm-81	0.9968	NA	0.9979	0.9974	0.9981	0.9974	0.9979
82	Vm-82	0.9885	0.9897	0.9898	0.9895	0.9903	0.9899	0.9904
83	Vm-83	0.9844	NA	0.9854	0.9851	0.9862	0.9856	0.9863

84	Vm-84	0.9797	NA	0.9796	0.9794	0.9813	0.9807	0.9818
85	Vm-85	0.9850	0.9763	0.9850	0.9848	0.9868	0.9860	0.9869
86	Vm-86	0.9867	0.9875	0.9867	0.9865	0.9884	0.9875	0.9884
87	Vm-87	1.0150	NA	1.0153	1.0151	1.0171	1.0160	1.0169
88	Vm-88	0.9875	NA	0.9873	0.9871	0.9895	0.9886	0.9895
89	Vm-89	1.0050	NA	1.0051	1.0049	1.0069	1.0061	1.0069
90	Vm-90	0.9850	NA	0.9852	0.9851	0.9869	0.9860	0.9868
91	Vm-91	0.9800	0.9868	0.9807	0.9806	0.9818	0.9811	0.9818
92	Vm-92	0.9900	0.9806	0.9903	0.9902	0.9919	0.9912	0.9919
93	Vm-93	0.9854	NA	0.9851	0.9850	0.9871	0.9865	0.9872
94	Vm-94	0.9898	0.9921	0.9913	0.9911	0.9918	0.9911	0.9917
95	Vm-95	0.9803	NA	0.9816	0.9813	0.9821	0.9814	0.9820
96	Vm-96	0.9923	NA	0.9937	0.9934	0.9941	0.9935	0.9941
97	Vm-97	1.0112	NA	1.0126	1.0122	1.0128	1.0122	1.0128
98	Vm-98	1.0235	NA	1.0249	1.0244	1.0249	1.0245	1.0249
99	Vm-99	1.0100	NA	1.0115	1.0112	1.0117	1.0114	1.0117
100	Vm-100	1.0170	1.0221	1.0182	1.0180	1.0183	1.0180	1.0182
101	Vm-101	0.9914	0.9859	0.9911	0.9909	0.9925	0.9927	0.9923
102	Vm-102	0.9891	0.9915	0.9891	0.9890	0.9907	0.9902	0.9907
103	Vm-103	1.0100	1.0141	1.0112	1.0110	1.0111	1.0110	1.0109
104	Vm-104	0.9710	NA	0.9727	0.9726	0.9725	0.9723	0.9722
105	Vm-105	0.9650	0.9742	0.9667	0.9666	0.9665	0.9663	0.9662
106	Vm-106	0.9611	NA	0.9631	0.9630	0.9628	0.9627	0.9627
107	Vm-107	0.9520	0.9527	0.9539	0.9538	0.9539	0.9535	0.9535
108	Vm-108	0.9662	NA	0.9676	0.9675	0.9675	0.9673	0.9672
109	Vm-109	0.9670	NA	0.9685	0.9684	0.9684	0.9682	0.9681
110	Vm-110	0.9730	0.9825	0.9743	0.9742	0.9746	0.9742	0.9745
111	Vm-111	0.9800	0.9782	0.9810	0.9810	0.9814	0.9811	0.9814
112	Vm-112	0.9750	0.9667	0.9757	0.9757	0.9765	0.9757	0.9765
113	Vm-113	0.9930	0.9858	1.0009	0.9930	0.9935	0.9925	0.9936
114	Vm-114	0.9601	0.9645	0.9659	0.9624	0.9609	0.9618	0.9611
115	Vm-115	0.9600	NA	0.9659	0.9623	0.9608	0.9618	0.9610
116	Vm-116	1.0050	NA	1.0057	1.0052	1.0061	1.0052	1.0059
117	Vm-117	0.9738	NA	0.9832	0.9745	0.9755	0.9736	0.9760
118	Vm-118	0.9494	NA	0.9496	0.9491	0.9501	0.9497	0.9500
119	PG-1	-0.5100	NA	-0.5272	-0.5132	-0.5168	-0.5173	-0.5185
120	PG-2	-0.2000	NA	-0.2000	-0.2067	-0.2052	-0.2052	-0.2052
121	PG-3	-0.3900	-0.3849	-0.4098	-0.3836	-0.3839	-0.3849	-0.3834
122	PG-4	-0.3900	-0.3958	-0.4925	-0.3958	-0.3948	-0.3958	-0.3973
123	PG-5	0.0000	NA	-1.0881	0.0153	0.0234	0.0031	-0.0114
124	PG-6	-0.5200	NA	-0.3491	-0.5095	-0.5081	-0.5094	-0.5080
125	PG-7	-0.1900	NA	-0.2828	-0.1977	-0.1947	-0.2014	-0.1991

126	PG-8	-0.2800	-0.2824	-0.2566	-0.2822	-0.2834	-0.2824	-0.2824
127	PG-9	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	0.0002
128	PG-10	4.5000	NA	4.5067	4.4836	4.4827	4.4838	4.4837
129	PG-11	-0.7000	NA	0.1313	-0.7032	-0.6977	-0.6949	-0.6912
130	PG-12	0.3800	0.3848	0.3674	0.3848	0.3858	0.3848	0.3840
131	PG-13	-0.3400	-0.3381	-0.3287	-0.3383	-0.3391	-0.3381	-0.3381
132	PG-14	-0.1400	NA	0.2966	-0.1497	-0.1414	-0.1339	-0.1378
133	PG-15	-0.9000	-0.8950	-0.9186	-0.8986	-1.0526	-0.8950	-0.8950
134	PG-16	-0.2500	-0.2480	-0.2600	-0.2480	-0.2470	-0.2480	-0.2480
135	PG-17	-0.1100	NA	-0.1299	-0.0584	-0.1867	-0.0699	-0.0935
136	PG-18	-0.6000	NA	-0.6193	-0.6023	-0.6317	-0.6027	-0.6061
137	PG-19	-0.4500	-0.4509	-0.4696	-0.4530	-0.4519	-0.4509	-0.4509
138	PG-20	-0.1800	-0.1776	-0.1929	-0.1808	-0.1786	-0.1807	-0.1776
139	PG-21	-0.1400	NA	-0.1507	-0.1401	-0.1329	-0.1414	-0.1450
140	PG-22	-0.1000	NA	-0.0943	-0.0903	-0.0970	-0.0918	-0.0847
141	PG-23	-0.0700	NA	-0.1059	-0.1081	-0.0993	-0.1104	-0.1034
142	PG-24	-0.1300	-0.1323	-0.1334	-0.1337	-0.1313	-0.1323	-0.1301
143	PG-25	2.2000	2.2435	2.2397	2.2399	2.2445	2.2470	2.2435
144	PG-26	3.1400	NA	3.1512	3.1191	3.1549	3.1238	3.1612
145	PG-27	-0.7100	NA	-0.7084	-0.7096	-0.7171	-0.7105	-0.7167
146	PG-28	-0.1700	NA	-0.1748	-0.1744	-0.1747	-0.1770	-0.1738
147	PG-29	-0.2400	NA	-0.2345	-0.2355	-0.2387	-0.2369	-0.2381
148	PG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
149	PG-31	-0.3600	-0.3664	-0.3641	-0.3644	-0.3654	-0.3664	-0.3649
150	PG-32	-0.5900	NA	-0.6130	-0.6073	-0.5959	-0.6037	-0.5949
151	PG-33	-0.2300	-0.2314	-0.2508	-0.2329	0.2304	-0.2314	-0.2314
152	PG-34	-0.5900	NA	-0.6350	-0.6126	-0.6510	-0.5972	-0.5981
153	PG-35	-0.3300	-0.3295	-0.3303	-0.3303	-0.3285	-0.3295	-0.3295
154	PG-36	-0.3100	-0.3044	-0.3053	-0.3051	-0.3034	-0.3044	-0.3044
155	PG-37	0.0000	NA	-0.0262	-0.0051	-0.1956	-0.0212	-0.0309
156	PG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	-0.0002
157	PG-39	-0.2700	NA	-0.2641	-0.2632	-0.2559	-0.2632	-0.2619
158	PG-40	-0.6600	NA	-0.6529	-0.6518	-0.6471	-0.6520	-0.6517
159	PG-41	-0.3700	NA	-0.3690	-0.3692	-0.3671	-0.3676	-0.3683
160	PG-42	-0.9600	-0.9690	-0.9676	-0.9675	-0.9680	-0.9690	-0.9690
161	PG-43	-0.1800	NA	-0.1810	-0.1810	-0.1794	-0.1804	-0.1802
162	PG-44	-0.1600	-0.1581	-0.1596	-0.1594	-0.1591	-0.1581	-0.1581
163	PG-45	-0.5300	NA	-0.5214	-0.5210	-0.5261	-0.5255	-0.5328
164	PG-46	-0.0900	-0.0884	-0.0907	-0.0907	-0.0894	-0.0907	-0.0899
165	PG-47	-0.3400	-0.3455	-0.3435	-0.3435	-0.3445	-0.3455	-0.3440
166	PG-48	-0.2000	NA	-0.2024	-0.2025	-0.2022	-0.2008	-0.1997
167	PG-49	1.1700	1.1639	1.1634	1.1634	1.1629	1.1639	1.1624

168	PG-50	-0.1700	NA	-0.1563	-0.1563	-0.1502	-0.1505	-0.1534
169	PG-51	-0.1700	NA	-0.1766	-0.1764	-0.1755	-0.1725	-0.1704
170	PG-52	-0.1800	-0.1806	-0.1819	-0.1819	-0.1816	-0.1829	-0.1822
171	PG-53	-0.2300	-0.2321	-0.2327	-0.2327	-0.2331	-0.2321	-0.2336
172	PG-54	-0.6500	-0.6479	-0.6472	-0.6472	-0.6489	-0.6486	-0.6492
173	PG-55	-0.6300	-0.6404	-0.6379	-0.6379	-0.6394	-0.6404	-0.6389
174	PG-56	-0.8400	NA	-0.8289	-0.8287	-0.8317	-0.8293	-0.8325
175	PG-57	-0.1200	NA	-0.1296	-0.1295	-0.1351	-0.1322	-0.1340
176	PG-58	-0.1200	NA	-0.1220	-0.1220	-0.1215	-0.1215	-0.1220
177	PG-59	-1.2200	NA	-1.2312	-1.2312	-1.2219	-1.2308	-1.2119
178	PG-60	-0.7800	NA	-0.7590	-0.7590	-0.7389	-0.7589	-0.7434
179	PG-61	1.6000	1.5911	1.5827	1.5827	1.5901	1.5827	1.5896
180	PG-62	-0.7700	NA	-0.7964	-0.7963	-0.8081	-0.7963	-0.7971
181	PG-63	0.0000	NA	0.0000	0.0000	-0.0163	0.0000	-0.0216
182	PG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
183	PG-65	3.9100	NA	3.9588	3.9409	3.9421	3.9361	3.9386
184	PG-66	3.5300	3.5670	3.5604	3.5603	3.5660	3.5603	3.5655
185	PG-67	-0.2800	NA	-0.2855	-0.2856	-0.3035	-0.2856	-0.3013
186	PG-68	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
187	PG-69	5.1386	NA	5.1304	5.1310	5.1225	5.1272	5.1226
188	PG-70	-0.6600	-0.6498	-0.6506	-0.6507	-0.6508	-0.6498	-0.6513
189	PG-71	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0002
190	PG-72	-0.1200	NA	-0.1236	-0.1240	-0.1211	-0.1247	-0.1215
191	PG-73	-0.0600	NA	-0.0601	-0.0604	-0.0601	-0.0591	-0.0591
192	PG-74	-0.6800	NA	-0.6739	-0.6734	-0.6735	-0.6735	-0.6751
193	PG-75	-0.4700	NA	-0.4864	-0.4860	-0.4864	-0.4843	-0.4854
194	PG-76	-0.6800	NA	-0.6804	-0.6806	-0.6808	-0.6816	-0.6791
195	PG-77	-0.6100	-0.6014	-0.6011	-0.6011	-0.6004	-0.6014	-0.5999
196	PG-78	-0.7100	NA	-0.7272	-0.7269	-0.7245	-0.7249	-0.7271
197	PG-79	-0.3900	-0.3952	-0.3960	-0.3960	-0.3962	-0.3952	-0.3951
198	PG-80	3.4700	NA	3.5013	3.5014	3.4963	3.5006	3.4988
199	PG-81	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0002
200	PG-82	-0.5400	NA	-0.5428	-0.5428	-0.5469	-0.5435	-0.5491
201	PG-83	-0.2000	-0.2017	-0.1981	-0.1982	-0.2007	-0.1982	-0.2002
202	PG-84	-0.1100	NA	-0.1092	-0.1091	-0.1112	-0.1088	-0.0994
203	PG-85	-0.2400	-0.2384	-0.2348	-0.2348	-0.2374	-0.2348	-0.2369
204	PG-86	-0.2100	-0.2101	-0.2093	-0.2093	-0.2099	-0.2101	-0.2114
205	PG-87	0.0400	NA	0.0402	0.0402	0.0388	0.0398	0.0398
206	PG-88	-0.4800	NA	-0.4896	-0.4896	-0.4819	-0.4882	-0.4880
207	PG-89	6.0700	NA	6.0799	6.0799	6.0977	6.0763	6.0782
208	PG-90	-1.6300	-1.6414	-1.6428	-1.6428	-1.6424	-1.6414	-1.6429
209	PG-91	-0.1000	NA	-0.0967	-0.0966	-0.0969	-0.0997	-0.0944

210	PG-92	-0.6500	-0.6440	-0.6454	-0.6454	-0.6450	-0.6440	-0.6455
211	PG-93	-0.1200	NA	-0.1137	-0.1136	-0.0990	-0.1096	-0.1059
212	PG-94	-0.3000	NA	-0.3017	-0.3018	-0.3224	-0.3054	-0.3123
213	PG-95	-0.4200	NA	-0.4251	-0.4251	-0.4257	-0.4278	-0.4251
214	PG-96	-0.3800	-0.3754	-0.3769	-0.3769	-0.3764	-0.3754	-0.3769
215	PG-97	-0.1500	-0.1484	-0.1495	-0.1495	-0.1494	-0.1484	-0.1499
216	PG-98	-0.3400	-0.3426	-0.3398	-0.3398	-0.3416	-0.3398	-0.3411
217	PG-99	-0.4200	-0.4243	-0.4213	-0.4213	-0.4233	-0.4243	-0.4243
218	PG-100	2.1500	NA	2.1305	2.1305	2.1301	2.1374	2.1370
219	PG-101	-0.2200	NA	-0.2175	-0.2175	-0.2209	-0.2177	-0.2179
220	PG-102	-0.0500	-0.0491	-0.0506	-0.0506	-0.0501	-0.0491	-0.0506
221	PG-103	0.1700	NA	0.1626	0.1625	0.1672	0.1658	0.1659
222	PG-104	-0.3800	-0.3732	-0.3713	-0.3713	-0.3722	-0.3713	-0.3717
223	PG-105	-0.3100	-0.3093	-0.3087	-0.3087	-0.3095	-0.3093	-0.3093
224	PG-106	-0.4300	NA	-0.4214	-0.4214	-0.4244	-0.4250	-0.4251
225	PG-107	-0.5000	NA	-0.5011	-0.5010	-0.5002	-0.5025	-0.5024
226	PG-108	-0.0200	NA	-0.0225	-0.0225	-0.0227	-0.0224	-0.0224
227	PG-109	-0.0800	NA	-0.0741	-0.0741	-0.0754	-0.0743	-0.0758
228	PG-110	-0.3900	-0.3969	-0.3960	-0.3960	-0.3959	-0.3969	-0.3954
229	PG-111	0.3600	0.3566	0.3572	0.3573	0.3568	0.3566	0.3566
230	PG-112	-0.6800	-0.6720	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
231	PG-113	-0.0600	NA	-0.0490	-0.0523	-0.0596	-0.0512	-0.0581
232	PG-114	-0.0800	NA	-0.0790	-0.0793	-0.0791	-0.0797	-0.0797
233	PG-115	-0.2200	NA	-0.2242	-0.2237	-0.2234	-0.2234	-0.2219
234	PG-116	-1.8400	-1.8683	-1.8445	-1.8444	-1.8321	-1.8444	-1.8310
235	PG-117	-0.2000	-0.1997	-0.2079	-0.1991	-0.1987	-0.1997	-0.1997
236	PG-118	-0.3300	-0.3321	-0.3291	-0.3291	-0.3311	-0.3291	-0.3306
237	QG-1	-0.3010	NA	-0.2919	-0.3000	-0.3014	-0.2996	-0.2967
238	QG-2	-0.0900	NA	-0.1323	-0.1039	-0.1062	-0.1063	-0.1017
239	QG-3	-0.1000	-0.1028	-0.0967	-0.1028	-0.1038	-0.1028	-0.1048
240	QG-4	-0.2701	-0.2755	-0.3077	-0.2757	-0.2745	-0.2745	-0.2735
241	QG-5	0.0000	NA	-0.1114	0.0104	0.0031	-0.0164	0.0159
242	QG-6	-0.0607	NA	-0.0453	-0.0676	-0.0637	-0.0644	-0.0677
243	QG-7	-0.0200	NA	-0.0076	-0.0197	-0.0217	-0.0197	-0.0197
244	QG-8	0.6314	0.6283	0.6576	0.6330	0.6293	0.6372	0.6283
245	QG-9	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
246	QG-10	-0.5104	NA	-0.4892	-0.5156	-0.5204	-0.5075	-0.5226
247	QG-11	-0.2300	NA	-0.4388	-0.2141	-0.2210	-0.2213	-0.2164
248	QG-12	0.8129	0.8385	0.8279	0.8376	0.8375	0.8341	0.8385
249	QG-13	-0.1600	0.1639	0.0288	-0.1641	-0.1648	-0.1646	-0.1563
250	QG-14	-0.0100	NA	0.0194	-0.0351	-0.0099	-0.0095	-0.0246
251	QG-15	-0.2284	-0.2335	-0.2458	-0.2362	-0.2345	-0.2335	-0.2341

252	QG-16	-0.1000	-0.1035	-0.1112	-0.1041	-0.1045	-0.1065	-0.1035
253	QG-17	-0.0300	NA	-0.0056	-0.0948	-0.0742	-0.0935	-0.0873
254	QG-18	-0.0557	NA	-0.0589	-0.0478	-0.0473	-0.0511	-0.0472
255	QG-19	-0.3927	-0.4078	-0.4116	-0.4071	-0.4068	-0.4078	-0.4058
256	QG-20	-0.0300	-0.0301	-0.0369	-0.0263	-0.0291	-0.0261	-0.0281
257	QG-21	-0.0800	NA	-0.0892	-0.0742	-0.0777	-0.0725	-0.0790
258	QG-22	-0.0500	NA	-0.0543	-0.0508	-0.0498	-0.0495	-0.0492
259	QG-23	-0.0300	NA	-0.0256	-0.0222	-0.0372	-0.0317	-0.0350
260	QG-24	-0.1491	-0.1525	-0.1522	-0.1542	-0.1535	-0.1525	-0.1525
261	QG-25	0.5004	0.5166	0.5125	0.5105	0.5156	0.5166	0.5146
262	QG-26	0.1012	NA	0.0873	0.0979	0.1140	0.1036	0.1155
263	QG-27	-0.0902	NA	-0.1003	-0.0852	-0.0922	-0.0823	-0.0905
264	QG-28	-0.0700	NA	-0.0787	-0.0728	-0.0698	-0.0734	-0.0683
265	QG-29	-0.0400	NA	-0.0387	-0.0398	-0.0426	-0.0379	-0.0429
266	QG-30	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	0.0004
267	QG-31	0.0559	0.0579	0.0565	0.0586	0.0589	0.0579	0.0593
268	QG-32	-0.3928	NA	-0.3964	-0.3747	-0.3868	-0.3743	-0.3919
269	QG-33	-0.0900	-0.0883	-0.0940	-0.0870	-0.0884	-0.0883	-0.0875
270	QG-34	-0.4683	NA	-0.4941	-0.4176	-0.4446	-0.4348	-0.4425
271	QG-35	-0.0900	-0.0909	-0.0901	-0.0894	-0.0899	-0.0893	-0.0889
272	QG-36	-0.0927	-0.0959	-0.0965	-0.0938	-0.0949	-0.0936	-0.0934
273	QG-37	0.0000	NA	0.1424	0.0099	0.0065	0.0134	-0.0020
274	QG-38	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
275	QG-39	-0.1100	NA	-0.1478	-0.1202	-0.1142	-0.1135	-0.1136
276	QG-40	0.0545	NA	0.0460	0.0585	0.0573	0.0603	0.0593
277	QG-41	-0.1000	NA	-0.0961	-0.0981	-0.0991	-0.0960	-0.0971
278	QG-42	0.1803	0.1818	0.1800	0.1806	0.1828	0.1818	0.1838
279	QG-43	-0.0700	NA	-0.0724	-0.0758	-0.0710	-0.0773	-0.0693
280	QG-44	-0.0800	-0.0780	-0.0865	-0.0875	-0.0770	-0.0875	-0.0780
281	QG-45	-0.2200	NA	-0.2299	-0.2175	-0.2172	-0.2158	-0.2142
282	QG-46	-0.1503	-0.1522	-0.1502	-0.1498	-0.1520	-0.1497	-0.1522
283	QG-47	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
284	QG-48	-0.1100	NA	-0.1060	-0.1051	-0.1116	-0.1050	-0.1129
285	QG-49	0.8585	0.8283	0.8330	0.8337	0.8293	0.8337	0.8283
286	QG-50	-0.0400	NA	-0.0347	-0.0344	-0.0404	-0.0353	-0.0420
287	QG-51	-0.0800	NA	-0.0661	-0.0641	-0.0761	-0.0672	-0.0767
288	QG-52	-0.0500	-0.0487	-0.0500	-0.0499	-0.0497	-0.0487	-0.0507
289	QG-53	-0.1100	-0.1082	-0.1152	-0.1143	-0.1092	-0.1114	-0.1096
290	QG-54	-0.2810	-0.2778	-0.2819	-0.2811	-0.2788	-0.2810	-0.2778
291	QG-55	-0.1734	-0.1737	-0.1743	-0.1739	-0.1727	-0.1737	-0.1717
292	QG-56	-0.2029	NA	-0.2207	-0.2181	-0.2079	-0.2150	-0.2035
293	QG-57	-0.0300	NA	-0.0351	-0.0342	-0.0228	-0.0332	-0.0235

294	QG-58	-0.0300	NA	-0.0278	-0.0277	-0.0298	-0.0266	-0.0290
295	QG-59	-0.3617	NA	-0.3490	-0.3506	-0.3660	-0.3576	-0.3735
296	QG-60	-0.0300	NA	-0.0307	-0.0307	-0.0235	-0.0252	-0.0313
297	QG-61	-0.4039	-0.3930	-0.3959	-0.3958	-0.3940	-0.3930	-0.3930
298	QG-62	-0.1274	NA	-0.1481	-0.1462	-0.1519	-0.1532	-0.1410
299	QG-63	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0003
300	QG-64	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
301	QG-65	0.8151	NA	0.7532	0.7909	0.8163	0.7961	0.8203
302	QG-66	-0.1996	-0.2026	-0.1968	-0.1967	-0.2016	-0.1949	-0.2026
303	QG-67	-0.0700	NA	-0.0624	-0.0623	-0.0625	-0.0660	-0.0631
304	QG-68	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0004
305	QG-69	-0.8242	NA	-0.7909	-0.7882	-0.8015	-0.7967	-0.7934
306	QG-70	-0.1033	-0.1048	-0.1013	-0.1005	-0.1038	-0.1015	-0.1048
307	QG-71	0.0000	NA	0.0000	0.0000	0.0010	0.0000	0.0004
308	QG-72	-0.1113	NA	-0.1041	-0.1045	-0.1080	-0.1060	-0.1101
309	QG-73	0.0965	NA	0.1039	0.1055	0.0969	0.1052	0.0959
310	QG-74	-0.3263	NA	-0.3334	-0.3311	-0.3285	-0.3307	-0.3267
311	QG-75	-0.1100	NA	-0.1386	-0.1344	-0.1184	-0.1194	-0.1199
312	QG-76	-0.3073	NA	-0.3166	-0.3160	-0.3163	-0.3172	-0.3179
313	QG-77	-0.1583	-0.1630	-0.1635	-0.1634	-0.1640	-0.1630	-0.1630
314	QG-78	-0.2600	NA	-0.2221	-0.2212	-0.2302	-0.2271	-0.2345
315	QG-79	-0.3200	-0.3166	-0.3147	-0.3145	-0.3156	-0.3151	-0.3166
316	QG-80	0.7947	NA	0.7948	0.7904	0.7852	0.7859	0.8062
317	QG-81	0.0000	NA	0.0000	0.0000	-0.0010	0.0000	-0.0172
318	QG-82	-0.2700	NA	-0.2716	-0.2705	-0.2713	-0.2630	-0.2706
319	QG-83	-0.1000	-0.0972	-0.0929	-0.0934	-0.0962	-0.1010	-0.0972
320	QG-84	-0.0700	NA	-0.0794	-0.0790	-0.0743	-0.0727	-0.0719
321	QG-85	-0.2061	-0.2070	-0.2108	-0.2107	-0.2080	-0.2107	-0.2090
322	QG-86	-0.1000	-0.0989	-0.1019	-0.1017	-0.1023	-0.1023	-0.1023
323	QG-87	0.1102	NA	0.1117	0.1118	0.1122	0.1112	0.1112
324	QG-88	-0.1000	NA	-0.1038	-0.1035	-0.0963	-0.0959	-0.0968
325	QG-89	-0.0590	-0.0584	-0.0627	-0.0626	-0.0594	-0.0626	-0.0584
326	QG-90	0.1731	0.1751	0.1728	0.1727	0.1761	0.1751	0.1751
327	QG-91	-0.1309	NA	-0.1227	-0.1221	-0.1340	-0.1315	-0.1344
328	QG-92	-0.2396	-0.2305	-0.2358	-0.2357	-0.2315	-0.2357	-0.2325
329	QG-93	-0.0700	NA	-0.1028	-0.1015	-0.0822	-0.0775	-0.0772
330	QG-94	-0.1600	NA	-0.1158	-0.1165	-0.1315	-0.1461	-0.1392
331	QG-95	-0.3100	NA	-0.3160	-0.3156	-0.3151	-0.3150	-0.3148
332	QG-96	-0.1500	-0.1482	-0.1496	-0.1493	-0.1481	-0.1482	-0.1482
333	QG-97	-0.0900	-0.0931	-0.0909	-0.0903	-0.0921	-0.0931	-0.0931
334	QG-98	-0.0800	-0.0825	-0.0814	-0.0816	-0.0815	-0.0816	-0.0825
335	QG-99	-0.1754	-0.1684	-0.1717	-0.1712	-0.1694	-0.1684	-0.1684

336	QG-100	0.7755	NA	0.7773	0.7780	0.7625	0.7615	0.7611
337	QG-101	-0.1500	NA	-0.1646	-0.1641	-0.1555	-0.1471	-0.1594
338	QG-102	-0.0300	-0.0298	-0.0333	-0.0331	-0.0308	-0.0331	-0.0298
339	QG-103	0.5942	NA	0.5883	0.5873	0.5829	0.5899	0.5826
340	QG-104	-0.2261	-0.2255	-0.2234	-0.2230	-0.2245	-0.2255	-0.2268
341	QG-105	-0.4433	-0.4472	-0.4438	-0.4437	-0.4462	-0.4450	-0.4472
342	QG-106	-0.1600	NA	-0.1549	-0.1547	-0.1579	-0.1550	-0.1534
343	QG-107	-0.0544	NA	-0.0543	-0.0537	-0.0522	-0.0538	-0.0532
344	QG-108	-0.0100	NA	-0.0169	-0.0166	-0.0155	-0.0176	-0.0181
345	QG-109	-0.0300	NA	-0.0275	-0.0275	-0.0317	-0.0264	-0.0317
346	QG-110	-0.2972	-0.2865	-0.2854	-0.2853	-0.2863	-0.2865	-0.2865
347	QG-111	-0.0184	-0.0186	-0.0210	-0.0208	-0.0196	-0.0186	-0.0186
348	QG-112	0.2851	0.2812	0.2728	0.2731	0.2802	0.2736	0.2812
349	QG-113	0.0675	NA	0.0676	0.0543	0.0686	0.0560	0.0673
350	QG-114	-0.0300	NA	-0.0330	-0.0290	-0.0300	-0.0300	-0.0300
351	QG-115	-0.0700	NA	-0.0692	-0.0696	-0.0709	-0.0709	-0.0709
352	QG-116	0.5132	0.4975	0.4896	0.4895	0.4944	0.4895	0.4934
353	QG-117	-0.0800	-0.0800	-0.0861	-0.0810	-0.0810	-0.0809	-0.0811
354	QG-118	-0.1500	-0.1544	-0.1543	-0.1543	-0.1536	-0.1535	-0.1544
355	PF 1-2	-0.1235	-0.1248	-0.1837	-0.1216	-0.1238	-0.1248	-0.1248
356	PF 1-3	-0.3865	NA	-0.3436	-0.3916	-0.3930	-0.3926	-0.3937
357	PF 4-5	-1.0323	NA	-0.7982	-1.0386	-1.0357	-1.0338	-1.0349
358	PF 3-5	-0.6811	-0.6751	-0.5839	-0.6805	-0.6811	-0.6805	-0.6804
359	PF 5-6	0.8847	0.8771	0.6123	0.8822	0.8797	0.8800	0.8786
360	PF 6-7	0.3554	0.3614	0.2589	0.3635	0.3624	0.3614	0.3614
361	PF 8-9	-4.4064	NA	-4.4140	-4.3909	-4.3891	-4.3909	-4.3912
362	PF 8-5	3.3847	NA	3.4972	3.3739	3.3587	3.3738	3.3874
363	PF 9-10	-4.4525	-4.4367	-4.4599	-4.4366	-4.4357	-4.4367	-4.4367
364	PF 4-11	0.6423	-0.6419	0.3058	0.6427	0.6409	0.6380	0.6376
365	PF 5-11	0.7722	0.7812	0.4042	0.7735	0.7713	0.7681	0.7678
366	PF 11-12	0.3429	NA	0.4570	0.3434	0.3449	0.3425	0.3448
367	PF 2-12	-0.3245	-0.3309	-0.3851	-0.3292	-0.3299	-0.3309	-0.3309
368	PF 3-12	-0.0979	NA	-0.1715	-0.0972	-0.0984	-0.0996	-0.0992
369	PF 7-12	0.1648	0.1617	-0.0243	0.1651	0.1671	0.1594	0.1617
370	PF 11-13	0.3509	NA	0.3790	0.3489	0.3490	0.3482	0.3490
371	PF 12-14	0.1831	-0.1837	-0.1032	0.1893	0.1827	0.1772	0.1808
372	PF 13-15	0.0077	NA	0.0471	0.0074	0.0068	0.0069	0.0078
373	PF 14-15	0.0424	0.0422	0.1932	0.0388	0.0405	0.0426	0.0422
374	PF 12-16	0.0751	NA	0.1292	0.0713	0.0807	0.0719	0.0725
375	PF 15-17	-1.0386	NA	-0.9739	-1.0458	-0.9839	-1.0401	-1.0384
376	PF 16-17	-0.1751	NA	-0.1312	-0.1769	-0.1665	-0.1763	-0.1757
377	PF 17-18	0.8027	0.8065	0.8105	0.8084	0.8055	0.8065	0.8065

378	PF 18-19	0.1939	NA	0.1824	0.1972	0.1650	0.1950	0.1916
379	PF 19-20	-0.1062	NA	-0.0845	-0.1052	-0.1103	-0.1040	-0.1104
380	PF 15-19	0.1153	NA	0.1843	0.1173	0.1435	0.1187	0.1168
381	PF 20-21	-0.2867	NA	-0.2778	-0.2864	-0.2893	-0.2851	-0.2884
382	PF 21-22	-0.4284	-0.4366	-0.4301	-0.4281	-0.4239	-0.4282	-0.4351
383	PF 22-23	-0.5326	NA	-0.5286	-0.5226	-0.5251	-0.5241	-0.5241
384	PF 23-24	0.0828	0.0828	0.0811	0.0801	0.0823	0.0801	0.0828
385	PF 23-25	-1.6256	NA	-1.6504	-1.6484	-1.6515	-1.6525	-1.6520
386	PF 26-25	0.9029	NA	0.8953	0.8948	0.9018	0.8950	0.9013
387	PF 25-27	1.4352	NA	1.4417	1.4432	1.4515	1.4462	1.4495
388	PF 27-28	0.3288	NA	0.3282	0.3294	0.3328	0.3322	0.3318
389	PF 28-29	0.1566	0.1557	0.1512	0.1528	0.1558	0.1529	0.1557
390	PF 30-17	2.3119	2.2708	2.2436	2.2856	2.3306	2.2881	2.3027
391	PF 8-30	0.7416	NA	0.6602	0.7348	0.7469	0.7348	0.7215
392	PF 26-30	2.2371	NA	2.2559	2.2244	2.2531	2.2288	2.2599
393	PF 17-31	0.1477	0.1473	0.1605	0.1564	0.1508	0.1573	0.1508
394	PF 29-31	-0.0842	NA	-0.0840	-0.0834	-0.0836	-0.0846	-0.0831
395	PF 23-32	0.9298	0.9357	0.9246	0.9276	0.9347	0.9279	0.9316
396	PF 31-32	-0.2986	NA	-0.2899	-0.2934	-0.3003	-0.2958	-0.2994
397	PF 27-32	0.1253	NA	0.1298	0.1291	0.1269	0.1285	0.1270
398	PF 15-33	0.0731	NA	0.1087	0.0757	-0.1653	0.0756	0.0763
399	PF 19-34	-0.0359	NA	-0.0200	-0.0346	-0.0344	-0.0345	-0.0335
400	PF 35-36	0.0084	NA	0.0091	0.0084	0.0123	0.0071	0.0070
401	PF 35-37	-0.3384	NA	-0.3394	-0.3387	-0.3408	-0.3366	-0.3366
402	PF 33-37	-0.1572	NA	-0.1427	-0.1575	0.0640	-0.1561	-0.1554
403	PF 34-36	0.3025	0.2981	0.2970	0.2975	0.2919	0.2981	0.2981
404	PF 34-37	-0.9431	NA	-0.9660	-0.9589	-0.9909	-0.9445	-0.9443
405	PF 38-37	2.4337	NA	2.4635	2.4470	2.4388	2.4448	2.4514
406	PF 37-39	0.5491	NA	0.5444	0.5435	0.5369	0.5435	0.5421
407	PF 37-40	0.4402	0.4325	0.4391	0.4375	0.4335	0.4372	0.4363
408	PF 30-38	0.6235	NA	0.6297	0.6308	0.6246	0.6326	0.6345
409	PF 39-40	0.2692	0.2706	0.2706	0.2706	0.2716	0.2706	0.2706
410	PF 40-41	0.1545	0.1569	0.1580	0.1577	0.1579	0.1569	0.1569
411	PF 40-42	-0.1184	NA	-0.1142	-0.1145	-0.1128	-0.1141	-0.1147
412	PF 41-42	-0.2159	NA	-0.2114	-0.2118	-0.2096	-0.2110	-0.2117
413	PF 43-44	-0.1659	-0.1655	-0.1677	-0.1676	-0.1665	-0.1666	-0.1663
414	PF 34-43	0.0141	0.0140	0.0134	0.0135	0.0130	0.0140	0.0140
415	PF 44-45	-0.3277	NA	-0.3291	-0.3288	-0.3274	-0.3265	-0.3262
416	PF 45-46	-0.3633	NA	-0.3597	-0.3594	-0.3613	-0.3602	-0.3639
417	PF 46-47	-0.3111	NA	-0.3094	-0.3092	-0.3094	-0.3092	-0.3111
418	PF 46-48	-0.1476	-0.1475	-0.1463	-0.1462	-0.1466	-0.1471	-0.1481
419	PF 47-49	-0.0954	NA	-0.0961	-0.0960	-0.0973	-0.0979	-0.0975

420	PF 42-49	-0.6487	NA	-0.6481	-0.6484	-0.6466	-0.6486	-0.6492
421	PF 42-49	-0.6487	NA	-0.6481	-0.6484	-0.6466	-0.6486	-0.6492
422	PF 45-49	-0.4970	-0.4872	-0.4935	-0.4931	-0.4948	-0.4943	-0.4978
423	PF 48-49	-0.3490	NA	-0.3501	-0.3500	-0.3502	-0.3492	-0.3492
424	PF 49-50	0.5366	NA	0.5313	0.5312	0.5291	0.5281	0.5301
425	PF 49-51	0.6663	NA	0.6741	0.6739	0.6737	0.6728	0.6705
426	PF 51-52	0.2856	NA	0.2871	0.2870	0.2874	0.2885	0.2885
427	PF 52-53	0.1037	0.1033	0.1033	0.1032	0.1039	0.1037	0.1044
428	PF 53-54	-0.1268	NA	-0.1300	-0.1300	-0.1298	-0.1290	-0.1298
429	PF 49-54	0.3777	NA	0.3797	0.3796	0.3805	0.3802	0.3795
430	PF 49-54	0.3774	NA	0.3795	0.3795	0.3802	0.3800	0.3792
431	PF 54-55	0.0707	0.0714	0.0723	0.0723	0.0725	0.0728	0.0721
432	PF 54-56	0.1853	NA	0.1861	0.1861	0.1874	0.1864	0.1864
433	PF 55-56	-0.2142	NA	-0.2210	-0.2210	-0.2208	-0.2228	-0.2199
434	PF 56-57	-0.2299	-0.2260	-0.2286	-0.2285	-0.2270	-0.2285	-0.2260
435	PF 50-57	0.3588	0.3629	0.3674	0.3672	0.3713	0.3700	0.3691
436	PF 56-58	-0.0667	NA	-0.0640	-0.0640	-0.0649	-0.0659	-0.0654
437	PF 51-58	0.1879	0.1886	0.1872	0.1872	0.1876	0.1886	0.1886
438	PF 54-59	-0.3038	NA	-0.3029	-0.3029	-0.3043	-0.3031	-0.3052
439	PF 56-59	-0.2796	NA	-0.2790	-0.2790	-0.2801	-0.2790	-0.2807
440	PF 56-59	-0.2931	NA	-0.2925	-0.2925	-0.2936	-0.2925	-0.2943
441	PF 55-59	-0.3452	NA	-0.3447	-0.3447	-0.3462	-0.3450	-0.3470
442	PF 59-60	-0.4332	-0.4372	-0.4344	-0.4344	-0.4362	-0.4345	-0.4356
443	PF 59-61	-0.5172	NA	-0.5174	-0.5174	-0.5182	-0.5175	-0.5177
444	PF 60-61	-1.1207	NA	-1.1089	-1.1089	-1.0995	-1.1089	-1.1000
445	PF 60-62	-0.0987	-0.1004	-0.0907	-0.0907	-0.0819	-0.0907	-0.0852
446	PF 61-62	0.2549	NA	0.2625	0.2626	0.2724	0.2625	0.2676
447	PF 63-59	1.5177	NA	1.5248	1.5247	1.5179	1.5247	1.5122
448	PF 63-64	-1.5177	NA	-1.5248	-1.5247	-1.5343	-1.5247	-1.5338
449	PF 64-61	0.3054	NA	0.3187	0.3187	0.3125	0.3187	0.3083
450	PF 38-65	-1.8128	NA	-1.8365	-1.8189	-1.8158	-1.8148	-1.8197
451	PF 64-65	-1.8279	-1.8604	-1.8483	-1.8483	-1.8527	-1.8483	-1.8472
452	PF 49-66	-1.3222	NA	-1.3269	-1.3268	-1.3264	-1.3264	-1.3282
453	PF 49-66	-1.3222	NA	-1.3269	-1.3268	-1.3264	-1.3264	-1.3282
454	PF 62-66	-0.3716	NA	-0.3782	-0.3782	-0.3788	-0.3782	-0.3768
455	PF 62-67	-0.2430	-0.2387	-0.2472	-0.2472	-0.2397	-0.2472	-0.2387
456	PF 65-66	0.0854	NA	0.0815	0.0814	0.0861	0.0807	0.0851
457	PF 66-67	0.5316	NA	0.5416	0.5416	0.5522	0.5417	0.5489
458	PF 65-68	0.1418	0.1442	0.1498	0.1500	0.1452	0.1500	0.1442
459	PF 47-69	-0.5594	-0.5525	-0.5603	-0.5603	-0.5603	-0.5604	-0.5612
460	PF 49-69	-0.4654	NA	-0.4659	-0.4659	-0.4657	-0.4657	-0.4665
461	PF 68-69	-1.2580	NA	-1.2467	-1.2466	-1.2422	-1.2466	-1.2432

462	PF 69-70	1.0838	NA	1.0857	1.0863	1.0825	1.0841	1.0809
463	PF 24-70	-0.0622	NA	-0.0666	-0.0668	-0.0633	-0.0660	-0.0625
464	PF 70-71	0.1665	NA	0.1710	0.1728	0.1694	0.1716	0.1671
465	PF 24-72	0.0147	NA	0.0140	0.0129	0.0140	0.0135	0.0150
466	PF 71-72	0.1060	0.1072	0.1103	0.1119	0.1078	0.1119	0.1072
467	PF 71-73	0.0601	0.0592	0.0603	0.0605	0.0602	0.0592	0.0592
468	PF 70-74	0.1621	NA	0.1625	0.1617	0.1631	0.1621	0.1638
469	PF 70-75	-0.0013	NA	0.0007	-0.0001	0.0018	0.0005	0.0021
470	PF 69-75	1.1001	1.1016	1.1027	1.1030	1.1026	1.1017	1.1016
471	PF 74-75	-0.5199	-0.5134	-0.5135	-0.5138	-0.5124	-0.5134	-0.5134
472	PF 76-77	-0.6115	-0.6192	-0.6138	-0.6141	-0.6141	-0.6139	-0.6129
473	PF 69-77	0.6221	NA	0.6193	0.6192	0.6195	0.6188	0.6194
474	PF 75-77	-0.3461	NA	-0.3490	-0.3493	-0.3488	-0.3487	-0.3483
475	PF 77-78	0.4539	NA	0.4684	0.4680	0.4668	0.4662	0.4685
476	PF 78-79	-0.2568	-0.2595	-0.2596	-0.2596	-0.2585	-0.2595	-0.2595
477	PF 77-80	-0.9657	NA	-0.9739	-0.9740	-0.9727	-0.9731	-0.9731
478	PF 77-80	-0.4437	NA	-0.4477	-0.4477	-0.4471	-0.4474	-0.4472
479	PF 79-80	-0.6474	NA	-0.6561	-0.6561	-0.6552	-0.6552	-0.6552
480	PF 68-81	-0.4415	NA	-0.4492	-0.4492	-0.4449	-0.4492	-0.4446
481	PF 81-80	-0.4420	-0.4435	-0.4498	-0.4497	-0.4445	-0.4497	-0.4450
482	PF 77-82	-0.0303	-0.0304	-0.0319	-0.0322	-0.0314	-0.0316	-0.0304
483	PF 82-83	-0.4722	NA	-0.4749	-0.4750	-0.4783	-0.4750	-0.4793
484	PF 83-84	-0.2479	NA	-0.2478	-0.2479	-0.2503	-0.2484	-0.2528
485	PF 83-85	-0.4277	NA	-0.4286	-0.4286	-0.4321	-0.4282	-0.4301
486	PF 84-85	-0.3635	-0.3682	-0.3627	-0.3628	-0.3672	-0.3628	-0.3580
487	PF 85-86	0.1717	NA	0.1709	0.1708	0.1728	0.1721	0.1734
488	PF 86-87	-0.0395	-0.0392	-0.0397	-0.0397	-0.0383	-0.0392	-0.0392
489	PF 85-88	-0.5039	-0.4945	-0.4990	-0.4990	-0.5070	-0.4998	-0.5000
490	PF 85-89	-0.7124	NA	-0.7114	-0.7114	-0.7161	-0.7114	-0.7116
491	PF 88-89	-0.9893	NA	-0.9939	-0.9939	-0.9943	-0.9933	-0.9933
492	PF 89-90	0.5822	NA	0.5850	0.5850	0.5855	0.5850	0.5847
493	PF 89-90	1.1083	NA	1.1138	1.1138	1.1146	1.1137	1.1130
494	PF 90-91	0.0141	NA	0.0092	0.0092	0.0110	0.0106	0.0082
495	PF 89-92	2.0154	NA	2.0138	2.0138	2.0223	2.0116	2.0137
496	PF 89-92	0.6359	NA	0.6354	0.6354	0.6381	0.6347	0.6354
497	PF 91-92	-0.0860	-0.0850	-0.0876	-0.0875	-0.0860	-0.0892	-0.0862
498	PF 92-93	0.5762	0.5728	0.5741	0.5741	0.5738	0.5728	0.5728
499	PF 92-94	0.5217	NA	0.5233	0.5233	0.5293	0.5233	0.5250
500	PF 93-94	0.4472	NA	0.4515	0.4516	0.4659	0.4543	0.4580
501	PF 94-95	0.4086	0.4122	0.4114	0.4114	0.4112	0.4122	0.4107
502	PF 80-96	0.1897	NA	0.1902	0.1902	0.1906	0.1906	0.1911
503	PF 82-96	-0.0994	-0.0979	-0.1013	-0.1015	-0.1014	-0.1015	-0.1016

504	PF 94-96	0.1979	NA	0.1978	0.1978	0.1972	0.1970	0.1971
505	PF 80-97	0.2642	NA	0.2645	0.2645	0.2648	0.2643	0.2655
506	PF 80-98	0.2895	NA	0.2900	0.2900	0.2914	0.2902	0.2912
507	PF 80-99	0.1956	NA	0.1966	0.1966	0.1976	0.1978	0.1980
508	PF 92-100	0.3150	0.3211	0.3162	0.3162	0.3192	0.3158	0.3164
509	PF 94-100	0.0428	NA	0.0439	0.0438	0.0440	0.0431	0.0430
510	PF 95-96	-0.0138	-0.0136	-0.0162	-0.0161	-0.0169	-0.0180	-0.0167
511	PF 96-97	-0.1110	NA	-0.1117	-0.1118	-0.1122	-0.1126	-0.1124
512	PF 98-100	-0.0526	-0.0517	-0.0519	-0.0519	-0.0522	-0.0517	-0.0519
513	PF 99-100	-0.2265	-0.2226	-0.2268	-0.2268	-0.2279	-0.2287	-0.2285
514	PF 100-101	-0.1674	-0.1698	-0.1694	-0.1694	-0.1708	-0.1698	-0.1698
515	PF 92-102	0.4465	NA	0.4467	0.4467	0.4511	0.4457	0.4475
516	PF 101-102	-0.3898	-0.3877	-0.3895	-0.3895	-0.3941	-0.3898	-0.3902
517	PF 100-103	1.2175	NA	1.2122	1.2122	1.2125	1.2136	1.2136
518	PF 100-104	0.5618	NA	0.5571	0.5571	0.5581	0.5583	0.5584
519	PF 103-104	0.3245	NA	0.3200	0.3199	0.3212	0.3211	0.3213
520	PF 103-105	0.4335	NA	0.4290	0.4289	0.4305	0.4307	0.4307
521	PF 100-106	0.6036	0.5930	0.5987	0.5987	0.6001	0.6007	0.6008
522	PF 104-105	0.4858	NA	0.4858	0.4857	0.4869	0.4879	0.4877
523	PF 105-105	0.0886	NA	0.0855	0.0855	0.0867	0.0877	0.0877
524	PF 105-107	0.2675	NA	0.2676	0.2675	0.2673	0.2686	0.2686
525	PF 105-108	0.2397	0.2396	0.2397	0.2397	0.2406	0.2396	0.2396
526	PF 106-107	0.2398	NA	0.2409	0.2409	0.2403	0.2413	0.2413
527	PF 108-109	0.2177	0.2154	0.2153	0.2153	0.2160	0.2154	0.2154
528	PF 103-110	0.6060	NA	0.6026	0.6026	0.6048	0.6043	0.6042
529	PF 109-110	0.1371	0.1389	0.1405	0.1405	0.1399	0.1404	0.1389
530	PF 110-111	-0.3570	NA	-0.3543	-0.3543	-0.3538	-0.3537	-0.3537

531	PF 110-112	0.6946	NA	0.6861	0.6861	0.6872	0.6861	0.6860
532	PF 17-113	0.0206	0.0206	0.0231	0.0222	0.0216	0.0206	0.0206
533	PF 32-113	0.0412	NA	0.0277	0.0316	0.0397	0.0319	0.0391
534	PF 32-114	0.0937	NA	0.0928	0.0932	0.0940	0.0936	0.0936
535	PF 27-115	0.2072	0.2104	0.2114	0.2108	0.2094	0.2104	0.2089
536	PF 114-115	0.0136	0.0138	0.0136	0.0137	0.0148	0.0138	0.0138
537	PF 68-116	1.8413	NA	1.8457	1.8457	1.8333	1.8457	1.8322
538	PF 12-117	0.2015	0.2001	0.2095	0.2006	0.2002	0.2012	0.2012
539	PF 75-118	0.4021	0.3946	0.3993	0.3992	0.4014	0.4004	0.4004
540	PF 76-118	-0.0685	-0.0676	-0.0666	-0.0665	-0.0666	-0.0676	-0.0661
541	PT 1-2	0.1245	NA	0.1851	0.1226	0.1247	0.1257	0.1257
542	PT 1-3	0.3890	NA	0.3456	0.3941	0.3956	0.3952	0.3963
543	PT 4-5	1.0343	NA	0.7995	1.0406	1.0377	1.0358	1.0369
544	PT 3-5	0.6935	NA	0.5930	0.6929	0.6935	0.6929	0.6927
545	PT 5-6	-0.8754	NA	-0.6079	-0.8730	-0.8705	-0.8708	-0.8694
546	PT 6-7	-0.3548	NA	-0.2585	-0.3628	-0.3618	-0.3608	-0.3608
547	PT 8-9	4.4525	NA	4.4599	4.4366	4.4347	4.4367	4.4369
548	PT 8-5	-3.3847	NA	-3.4972	-3.3739	-3.3587	-3.3738	-3.3874
549	PT 9-10	4.5000	NA	4.5067	4.4836	4.4827	4.4838	4.4837
550	PT 4-11	-0.6336	NA	-0.3038	-0.6341	-0.6323	-0.6294	-0.6291
551	PT 5-11	-0.7602	NA	-0.4009	-0.7614	-0.7592	-0.7561	-0.7559
552	PT 11-12	-0.3415	-0.3444	-0.4550	-0.3420	-0.3434	-0.3410	-0.3433
553	PT 2-12	0.3273	NA	0.3889	0.3322	0.3329	0.3340	0.3339
554	PT 3-12	0.0989	NA	0.1735	0.0983	0.0995	0.1007	0.1003
555	PT 7-12	-0.1645	NA	0.0243	-0.1648	-0.1668	-0.1592	-0.1614
556	PT 11-13	-0.3477	-0.3450	-0.3758	-0.3457	-0.3458	-0.3450	-0.3458
557	PT 12-14	-0.1824	NA	0.1034	-0.1885	-0.1819	-0.1765	-0.1801
558	PT 13-15	-0.0077	-0.0078	-0.0469	-0.0074	-0.0068	-0.0069	-0.0078
559	PT 14-15	-0.0421	NA	-0.1907	-0.0385	-0.0402	-0.0423	-0.0419
560	PT 12-16	-0.0749	NA	-0.1288	-0.0711	-0.0805	-0.0717	-0.0723
561	PT 15-17	1.0544	1.0682	0.9877	1.0618	0.9981	1.0559	1.0542
562	PT 16-17	0.1766	NA	0.1320	0.1784	0.1678	0.1778	0.1772
563	PT 17-18	-0.7939	NA	-0.8016	-0.7996	-0.7967	-0.7977	-0.7977
564	PT 18-19	-0.1931	-0.1964	-0.1816	-0.1964	-0.1643	-0.1942	-0.1908
565	PT 19-20	0.1067	NA	0.0849	0.1056	0.1107	0.1044	0.1108
566	PT 15-19	-0.1147	NA	-0.1835	-0.1169	-0.1429	-0.1182	-0.1163
567	PT 20-21	0.2884	0.2920	0.2794	0.2880	0.2910	0.2867	0.2901
568	PT 21-22	0.4326	0.4249	0.4343	0.4323	0.4280	0.4323	0.4394
569	PT 22-23	0.5430	0.5341	0.5388	0.5326	0.5351	0.5341	0.5341
570	PT 23-24	-0.0825	NA	-0.0808	-0.0798	-0.0820	-0.0798	-0.0825

571	PT 23-25	1.6676	1.6958	1.6932	1.6914	1.6948	1.6958	1.6953
572	PT 26-25	-0.9029	-0.9028	-0.8953	-0.8948	-0.9018	-0.8950	-0.9013
573	PT 25-27	-1.3713	NA	-1.3778	-1.3788	-1.3862	-1.3815	-1.3844
574	PT 27-28	-0.3266	-0.3295	-0.3261	-0.3272	-0.3305	-0.3299	-0.3295
575	PT 28-29	-0.1558	NA	-0.1505	-0.1521	-0.1551	-0.1522	-0.1550
576	PT 30-17	-2.3119	NA	-2.2436	-2.2856	-2.3306	-2.2881	-2.3027
577	PT 8-30	-0.7381	-0.7443	-0.6572	-0.7312	-0.7433	-0.7313	-0.7180
578	PT 26-30	-2.1973	NA	-2.2160	-2.1851	-2.2129	-2.1894	-2.2195
579	PT 17-31	-0.1457	NA	-0.1583	-0.1545	-0.1489	-0.1554	-0.1488
580	PT 29-31	0.0843	0.0848	0.0841	0.0835	0.0838	0.0848	0.0833
581	PT 23-32	-0.9020	NA	-0.8974	-0.9001	-0.9067	-0.9002	-0.9037
582	PT 31-32	0.3020	NA	0.2932	0.2966	0.3037	0.2991	0.3028
583	PT 27-32	-0.1249	NA	-0.1294	-0.1286	-0.1265	-0.1281	-0.1266
584	PT 15-33	-0.0728	NA	-0.1082	-0.0754	0.1664	-0.0753	-0.0760
585	PT 19-34	0.0365	0.0360	0.0206	0.0352	0.0350	0.0352	0.0341
586	PT 35-36	-0.0084	NA	-0.0091	-0.0084	-0.0123	-0.0070	-0.0070
587	PT 35-37	0.3399	0.3413	0.3409	0.3402	0.3423	0.3380	0.3380
588	PT 33-37	0.1586	0.1581	0.1439	0.1590	-0.0634	0.1576	0.1569
589	PT 34-36	-0.3016	NA	-0.2962	-0.2967	-0.2911	-0.2973	-0.2973
590	PT 34-37	0.9459	NA	0.9690	0.9617	0.9939	0.9473	0.9471
591	PT 38-37	-2.4337	NA	-2.4635	-2.4470	-2.4388	-2.4448	-2.4514
592	PT 37-39	-0.5392	NA	-0.5347	-0.5338	-0.5275	-0.5338	-0.5325
593	PT 37-40	-0.4285	NA	-0.4276	-0.4260	-0.4222	-0.4257	-0.4249
594	PT 30-38	-0.6209	-0.6122	-0.6270	-0.6282	-0.6221	-0.6300	-0.6319
595	PT 39-40	-0.2676	NA	-0.2690	-0.2690	-0.2700	-0.2690	-0.2690
596	PT 40-41	-0.1541	NA	-0.1576	-0.1574	-0.1575	-0.1565	-0.1565
597	PT 40-42	0.1193	0.1197	0.1150	0.1154	0.1136	0.1150	0.1155
598	PT 41-42	0.2181	0.2177	0.2135	0.2139	0.2117	0.2131	0.2139
599	PT 43-44	0.1677	NA	0.1696	0.1694	0.1683	0.1684	0.1681
600	PT 34-43	-0.0141	NA	-0.0133	-0.0134	-0.0129	-0.0139	-0.0139
601	PT 44-45	0.3303	NA	0.3317	0.3314	0.3300	0.3290	0.3288
602	PT 45-46	0.3687	NA	0.3650	0.3647	0.3667	0.3656	0.3693
603	PT 46-47	0.3148	0.3201	0.3130	0.3128	0.3130	0.3128	0.3147
604	PT 46-48	0.1490	NA	0.1477	0.1475	0.1480	0.1484	0.1495
605	PT 47-49	0.0957	NA	0.0965	0.0964	0.0976	0.0983	0.0979
606	PT 42-49	0.6804	0.6887	0.6796	0.6800	0.6780	0.6802	0.6808
607	PT 42-49	0.6804	0.6755	0.6796	0.6800	0.6780	0.6802	0.6808
608	PT 45-49	0.5144	NA	0.5106	0.5101	0.5120	0.5115	0.5151
609	PT 48-49	0.3511	0.3514	0.3522	0.3522	0.3524	0.3514	0.3514
610	PT 49-50	-0.5288	-0.5205	-0.5236	-0.5235	-0.5215	-0.5205	-0.5225
611	PT 49-51	-0.6435	-0.6555	-0.6509	-0.6507	-0.6505	-0.6497	-0.6475
612	PT 51-52	-0.2837	-0.2866	-0.2852	-0.2851	-0.2855	-0.2866	-0.2866

613	PT 52-53	-0.1032	NA	-0.1027	-0.1027	-0.1034	-0.1031	-0.1038
614	PT 53-54	0.1274	NA	0.1306	0.1305	0.1303	0.1296	0.1304
615	PT 49-54	-0.3658	-0.3600	-0.3676	-0.3676	-0.3685	-0.3681	-0.3675
616	PT 49-54	-0.3638	NA	-0.3657	-0.3656	-0.3664	-0.3662	-0.3655
617	PT 54-55	-0.0706	NA	-0.0722	-0.0722	-0.0724	-0.0726	-0.0720
618	PT 54-56	-0.1852	-0.1863	-0.1860	-0.1860	-0.1873	-0.1863	-0.1863
619	PT 55-56	0.2145	0.2185	0.2213	0.2213	0.2211	0.2230	0.2201
620	PT 56-57	0.2321	NA	0.2308	0.2307	0.2292	0.2307	0.2281
621	PT 50-57	-0.3521	NA	-0.3604	-0.3602	-0.3642	-0.3630	-0.3621
622	PT 56-58	0.0669	0.0661	0.0642	0.0642	0.0651	0.0661	0.0656
623	PT 51-58	-0.1869	NA	-0.1862	-0.1862	-0.1866	-0.1876	-0.1876
624	PT 54-59	0.3090	0.3031	0.3081	0.3081	0.3095	0.3083	0.3104
625	PT 56-59	0.2867	NA	0.2861	0.2861	0.2872	0.2861	0.2879
626	PT 56-59	0.3007	0.3039	0.3001	0.3001	0.3012	0.3001	0.3019
627	PT 55-59	0.3516	NA	0.3511	0.3511	0.3526	0.3514	0.3535
628	PT 59-60	0.4394	NA	0.4406	0.4406	0.4425	0.4408	0.4419
629	PT 59-61	0.5264	0.5182	0.5266	0.5266	0.5275	0.5267	0.5269
630	PT 60-61	1.1241	1.1018	1.1122	1.1122	1.1028	1.1122	1.1033
631	PT 60-62	0.0989	NA	0.0909	0.0909	0.0820	0.0909	0.0853
632	PT 61-62	-0.2542	NA	-0.2618	-0.2619	-0.2716	-0.2618	-0.2669
633	PT 63-59	-1.5177	-1.5040	-1.5248	-1.5247	-1.5179	-1.5247	-1.5122
634	PT 63-64	1.5225	1.5402	1.5296	1.5296	1.5392	1.5296	1.5387
635	PT 64-61	-0.3054	NA	-0.3187	-0.3187	-0.3125	-0.3187	-0.3083
636	PT 38-65	1.8449	NA	1.8690	1.8511	1.8479	1.8469	1.8519
637	PT 64-65	1.8378	NA	1.8585	1.8585	1.8629	1.8585	1.8573
638	PT 49-66	1.3522	1.3473	1.3571	1.3570	1.3566	1.3566	1.3585
639	PT 49-66	1.3522	NA	1.3571	1.3570	1.3566	1.3566	1.3585
640	PT 62-66	0.3793	0.3833	0.3861	0.3861	0.3868	0.3862	0.3847
641	PT 62-67	0.2450	NA	0.2493	0.2492	0.2416	0.2492	0.2406
642	PT 65-66	-0.0854	-0.0871	-0.0815	-0.0814	-0.0861	-0.0807	-0.0851
643	PT 66-67	-0.5250	-0.5210	-0.5348	-0.5348	-0.5451	-0.5348	-0.5419
644	PT 65-68	-0.1418	NA	-0.1498	-0.1499	-0.1452	-0.1499	-0.1442
645	PT 47-69	0.5868	NA	0.5877	0.5877	0.5877	0.5879	0.5887
646	PT 49-69	0.4878	0.4913	0.4883	0.4883	0.4880	0.4881	0.4889
647	PT 68-69	1.2580	1.2432	1.2467	1.2466	1.2422	1.2466	1.2432
648	PT 69-70	-1.0494	NA	-1.0514	-1.0519	-1.0483	-1.0499	-1.0468
649	PT 24-70	0.0622	0.0617	0.0666	0.0668	0.0633	0.0660	0.0625
650	PT 70-71	-0.1661	NA	-0.1706	-0.1724	-0.1690	-0.1711	-0.1667
651	PT 24-72	-0.0145	-0.0148	-0.0138	-0.0127	-0.0139	-0.0134	-0.0148
652	PT 71-72	-0.1055	NA	-0.1098	-0.1113	-0.1072	-0.1113	-0.1067
653	PT 71-73	-0.0600	NA	-0.0601	-0.0604	-0.0601	-0.0591	-0.0591
654	PT 70-74	-0.1601	-0.1601	-0.1604	-0.1596	-0.1611	-0.1601	-0.1618

655	PT 70-75	0.0019	NA	0.0001	0.0008	-0.0011	0.0002	-0.0015
656	PT 69-75	-1.0516	NA	-1.0539	-1.0541	-1.0538	-1.0530	-1.0529
657	PT 74-75	0.5236	NA	0.5171	0.5174	0.5159	0.5169	0.5169
658	PT 76-77	0.6321	NA	0.6347	0.6350	0.6349	0.6348	0.6337
659	PT 69-77	-0.6105	-0.6042	-0.6078	-0.6077	-0.6080	-0.6073	-0.6079
660	PT 75-77	0.3541	0.3483	0.3572	0.3575	0.3570	0.3569	0.3565
661	PT 77-78	-0.4532	NA	-0.4676	-0.4672	-0.4660	-0.4654	-0.4676
662	PT 78-79	0.2574	NA	0.2602	0.2602	0.2590	0.2600	0.2600
663	PT 77-80	0.9834	NA	0.9918	0.9918	0.9905	0.9909	0.9910
664	PT 77-80	0.4505	NA	0.4546	0.4546	0.4540	0.4542	0.4541
665	PT 79-80	0.6550	0.6666	0.6639	0.6639	0.6629	0.6629	0.6629
666	PT 68-81	0.4420	NA	0.4498	0.4497	0.4455	0.4497	0.4452
667	PT 81-80	0.4420	NA	0.4498	0.4497	0.4445	0.4497	0.4450
668	PT 77-82	0.0317	NA	0.0334	0.0337	0.0328	0.0330	0.0318
669	PT 82-83	0.4756	0.4827	0.4783	0.4784	0.4817	0.4784	0.4827
670	PT 83-84	0.2535	NA	0.2536	0.2537	0.2560	0.2540	0.2586
671	PT 83-85	0.4367	NA	0.4377	0.4377	0.4412	0.4372	0.4391
672	PT 84-85	0.3679	NA	0.3672	0.3672	0.3717	0.3672	0.3623
673	PT 85-86	-0.1705	-0.1726	-0.1697	-0.1697	-0.1716	-0.1709	-0.1721
674	PT 86-87	0.0400	0.0398	0.0402	0.0402	0.0388	0.0398	0.0398
675	PT 85-88	0.5093	NA	0.5043	0.5044	0.5124	0.5051	0.5053
676	PT 85-89	0.7249	NA	0.7239	0.7239	0.7287	0.7239	0.7240
677	PT 88-89	1.0033	1.0074	1.0080	1.0080	1.0084	1.0074	1.0074
678	PT 89-90	-0.5648	NA	-0.5675	-0.5675	-0.5680	-0.5675	-0.5672
679	PT 89-90	-1.0793	-1.0881	-1.0846	-1.0846	-1.0855	-1.0846	-1.0840
680	PT 90-91	-0.0140	NA	-0.0091	-0.0091	-0.0109	-0.0105	-0.0081
681	PT 89-92	-1.9756	NA	-1.9740	-1.9740	-1.9824	-1.9720	-1.9741
682	PT 89-92	-0.6202	NA	-0.6196	-0.6196	-0.6223	-0.6190	-0.6197
683	PT 91-92	0.0864	NA	0.0880	0.0879	0.0864	0.0896	0.0866
684	PT 92-93	-0.5672	NA	-0.5652	-0.5652	-0.5649	-0.5639	-0.5639
685	PT 92-94	-0.5075	-0.5024	-0.5089	-0.5089	-0.5147	-0.5090	-0.5106
686	PT 93-94	-0.4418	NA	-0.4458	-0.4459	-0.4601	-0.4488	-0.4524
687	PT 94-95	-0.4062	NA	-0.4090	-0.4090	-0.4088	-0.4098	-0.4083
688	PT 80-96	-0.1866	NA	-0.1871	-0.1872	-0.1875	-0.1875	-0.1880
689	PT 82-96	0.0996	NA	0.1015	0.1017	0.1016	0.1017	0.1018
690	PT 94-96	-0.1966	-0.1949	-0.1965	-0.1965	-0.1959	-0.1957	-0.1958
691	PT 80-97	-0.2618	NA	-0.2621	-0.2621	-0.2624	-0.2619	-0.2631
692	PT 80-98	-0.2874	-0.2837	-0.2879	-0.2879	-0.2893	-0.2882	-0.2891
693	PT 80-99	-0.1935	NA	-0.1945	-0.1945	-0.1954	-0.1956	-0.1958
694	PT 92-100	-0.3071	NA	-0.3082	-0.3082	-0.3111	-0.3079	-0.3086
695	PT 94-100	-0.0387	-0.0390	-0.0398	-0.0397	-0.0400	-0.0390	-0.0390
696	PT 95-96	0.0145	NA	0.0170	0.0169	0.0177	0.0188	0.0175

697	PT 96-97	0.1118	0.1119	0.1126	0.1126	0.1130	0.1135	0.1132
698	PT 98-100	0.0528	NA	0.0521	0.0521	0.0524	0.0519	0.0521
699	PT 99-100	0.2274	NA	0.2278	0.2278	0.2288	0.2296	0.2294
700	PT 100-101	0.1698	NA	0.1720	0.1720	0.1732	0.1722	0.1722
701	PT 92-102	-0.4439	NA	-0.4441	-0.4441	-0.4485	-0.4431	-0.4449
702	PT 101-102	0.3939	NA	0.3936	0.3936	0.3983	0.3940	0.3943
703	PT 100-103	-1.1940	-1.1903	-1.1890	-1.1890	-1.1893	-1.1903	-1.1903
704	PT 100-104	-0.5473	NA	-0.5429	-0.5429	-0.5438	-0.5439	-0.5440
705	PT 103-104	-0.3185	NA	-0.3142	-0.3141	-0.3154	-0.3153	-0.3154
706	PT 103-105	-0.4225	NA	-0.4182	-0.4181	-0.4196	-0.4198	-0.4199
707	PT 100-106	-0.5814	NA	-0.5769	-0.5768	-0.5781	-0.5787	-0.5788
708	PT 104-105	-0.4833	-0.4854	-0.4833	-0.4832	-0.4844	-0.4854	-0.4852
709	PT 105-105	-0.0885	-0.0875	-0.0854	-0.0854	-0.0865	-0.0876	-0.0875
710	PT 105-107	-0.2635	NA	-0.2635	-0.2635	-0.2632	-0.2645	-0.2645
711	PT 105-108	-0.2377	NA	-0.2378	-0.2378	-0.2387	-0.2377	-0.2377
712	PT 106-107	-0.2365	-0.2379	-0.2376	-0.2375	-0.2369	-0.2379	-0.2379
713	PT 108-109	-0.2171	-0.2143	-0.2147	-0.2147	-0.2153	-0.2147	-0.2147
714	PT 103-110	-0.5915	NA	-0.5883	-0.5883	-0.5904	-0.5899	-0.5899
715	PT 109-110	-0.1361	NA	-0.1395	-0.1395	-0.1388	-0.1393	-0.1378
716	PT 110-111	0.3600	NA	0.3572	0.3573	0.3568	0.3566	0.3566
717	PT 110-112	-0.6800	NA	-0.6720	-0.6720	-0.6730	-0.6720	-0.6718
718	PT 17-113	-0.0205	NA	-0.0230	-0.0221	-0.0216	-0.0206	-0.0206
719	PT 32-113	-0.0395	-0.0390	-0.0260	-0.0302	-0.0380	-0.0306	-0.0375
720	PT 32-114	-0.0936	-0.0934	-0.0927	-0.0930	-0.0938	-0.0934	-0.0934
721	PT 27-115	-0.2064	NA	-0.2106	-0.2099	-0.2086	-0.2096	-0.2081

722	PT 114-115	-0.0136	NA	-0.0136	-0.0137	-0.0148	-0.0138	-0.0138
723	PT 68-116	-1.8400	-1.8256	-1.8445	-1.8444	-1.8321	-1.8444	-1.8310
724	PT 12-117	-0.2000	NA	-0.2079	-0.1991	-0.1987	-0.1997	-0.1997
725	PT 75-118	-0.3987	NA	-0.3959	-0.3958	-0.3980	-0.3970	-0.3970
726	PT 76-118	0.0687	NA	0.0669	0.0667	0.0669	0.0679	0.0664
727	QF 1-2	-0.1304	-0.1267	-0.1144	-0.1266	-0.1277	-0.1267	-0.1267
728	QF 1-3	-0.1706	NA	-0.1775	-0.1734	-0.1737	-0.1729	-0.1700
729	QF 4-5	-0.2679	NA	-0.3004	-0.2749	-0.2714	-0.2713	-0.2705
730	QF 3-5	-0.1449	-0.1483	-0.1485	-0.1499	-0.1493	-0.1483	-0.1483
731	QF 5-6	0.0411	0.0415	0.0022	0.0483	0.0428	0.0428	0.0457
732	QF 6-7	-0.0477	-0.0493	-0.0488	-0.0471	-0.0483	-0.0493	-0.0493
733	QF 8-9	-0.8973	NA	-0.9696	-0.9112	-0.9100	-0.9136	-0.9093
734	QF 8-5	1.2473	NA	1.3580	1.2571	1.2491	1.2708	1.2414
735	QF 9-10	-0.2443	-0.2443	-0.2955	-0.2492	-0.2453	-0.2547	-0.2443
736	QF 4-11	-0.0022	-0.0021	-0.0073	-0.0008	-0.0031	-0.0032	-0.0031
737	QF 5-11	0.0297	0.0290	0.0246	0.0319	0.0290	0.0290	0.0290
738	QF 11-12	-0.3514	NA	-0.3656	-0.3377	-0.3487	-0.3479	-0.3402
739	QF 2-12	-0.2001	-0.2066	-0.2276	-0.2100	-0.2135	-0.2127	-0.2079
740	QF 3-12	-0.1240	NA	-0.1223	-0.1247	-0.1267	-0.1259	-0.1249
741	QF 7-12	-0.0651	-0.0664	-0.0523	-0.0643	-0.0674	-0.0664	-0.0664
742	QF 11-13	0.1141	NA	-0.0386	0.1200	0.1194	0.1184	0.1163
743	QF 12-14	0.0262	-0.0261	-0.0014	0.0473	0.0279	0.0265	0.0424
744	QF 13-15	-0.0384	NA	-0.0019	-0.0366	-0.0378	-0.0386	-0.0324
745	QF 14-15	0.0314	0.0323	0.0355	0.0271	0.0333	0.0323	0.0330
746	QF 12-16	0.0430	NA	0.0462	0.0493	0.0488	0.0498	0.0525
747	QF 15-17	-0.2427	NA	-0.2437	-0.2359	-0.2415	-0.2335	-0.2339
748	QF 16-17	-0.0368	NA	-0.0453	-0.0346	-0.0356	-0.0367	-0.0308
749	QF 17-18	0.2476	0.2400	0.2560	0.2388	0.2410	0.2400	0.2400
750	QF 18-19	0.1683	NA	0.1735	0.1672	0.1701	0.1651	0.1692
751	QF 19-20	0.0517	NA	0.0647	0.0403	0.0486	0.0391	0.0486
752	QF 15-19	0.1572	NA	0.1784	0.1512	0.1584	0.1534	0.1585
753	QF 20-21	0.0471	NA	0.0539	0.0398	0.0450	0.0388	0.0459
754	QF 21-22	-0.0210	-0.0214	-0.0227	-0.0223	-0.0209	-0.0216	-0.0212
755	QF 22-23	-0.0676	NA	-0.0734	-0.0695	-0.0668	-0.0675	-0.0674
756	QF 23-24	0.1042	0.1059	0.1160	0.1093	0.1049	0.1052	0.1059
757	QF 23-25	-0.2616	NA	-0.2699	-0.2583	-0.2672	-0.2615	-0.2675
758	QF 26-25	0.2158	NA	0.2183	0.2066	0.2202	0.2069	0.2212
759	QF 25-27	0.3006	NA	0.3042	0.3008	0.3083	0.3026	0.3079
760	QF 27-28	-0.0059	NA	-0.0044	-0.0011	-0.0051	-0.0007	-0.0057
761	QF 28-29	-0.0657	-0.0639	-0.0725	-0.0636	-0.0649	-0.0639	-0.0639
762	QF 30-17	0.9297	0.9583	0.9096	0.9603	0.9573	0.9583	0.9583

763	QF 8-30	0.2815	NA	0.2692	0.2871	0.2901	0.2800	0.2962
764	QF 26-30	-0.1146	NA	-0.1310	-0.1087	-0.1062	-0.1032	-0.1057
765	QF 17-31	0.1152	0.1136	0.1226	0.1021	0.1126	0.1018	0.1120
766	QF 29-31	-0.0864	NA	-0.0915	-0.0839	-0.0882	-0.0824	-0.0875
767	QF 23-32	0.0505	0.0496	0.0471	0.0502	0.0506	0.0496	0.0517
768	QF 31-32	0.1240	NA	0.1268	0.1163	0.1226	0.1168	0.1232
769	QF 27-32	0.0176	NA	0.0136	0.0175	0.0166	0.0184	0.0185
770	QF 15-33	-0.0442	NA	-0.0457	-0.0551	-0.0499	-0.0540	-0.0519
771	QF 19-34	-0.1040	NA	-0.1100	-0.1141	-0.1117	-0.1134	-0.1117
772	QF 35-36	0.0404	NA	0.0461	0.0380	0.0397	0.0395	0.0393
773	QF 35-37	-0.1304	NA	-0.1362	-0.1274	-0.1296	-0.1288	-0.1282
774	QF 33-37	-0.1049	NA	-0.1107	-0.1130	-0.1116	-0.1131	-0.1102
775	QF 34-36	0.0470	0.0486	0.0447	0.0503	0.0496	0.0486	0.0486
776	QF 34-37	-0.4420	NA	-0.4846	-0.4144	-0.4295	-0.4290	-0.4255
777	QF 38-37	1.1360	NA	1.1039	1.1138	1.1203	1.1151	1.1250
778	QF 37-39	0.0298	NA	0.0637	0.0362	0.0303	0.0294	0.0294
779	QF 37-40	-0.0368	-0.0380	-0.0171	-0.0338	-0.0370	-0.0380	-0.0380
780	QF 30-38	0.1903	NA	0.2058	0.1814	0.1777	0.1784	0.1845
781	QF 39-40	-0.0870	-0.0899	-0.0899	-0.0899	-0.0889	-0.0899	-0.0899
782	QF 40-41	0.0119	0.0116	0.0153	0.0136	0.0126	0.0116	0.0116
783	QF 40-42	-0.0645	NA	-0.0582	-0.0614	-0.0631	-0.0618	-0.0626
784	QF 41-42	-0.0779	NA	-0.0705	-0.0743	-0.0762	-0.0741	-0.0752
785	QF 43-44	-0.0133	-0.0136	0.0007	-0.0089	-0.0126	-0.0108	-0.0118
786	QF 34-43	0.0163	0.0169	0.0324	0.0266	0.0179	0.0262	0.0169
787	QF 44-45	0.0548	NA	0.0628	0.0517	0.0593	0.0498	0.0590
788	QF 45-46	-0.0357	NA	-0.0369	-0.0365	-0.0321	-0.0366	-0.0309
789	QF 46-47	-0.0122	NA	-0.0124	-0.0119	-0.0113	-0.0120	-0.0111
790	QF 46-48	-0.0583	-0.0561	-0.0586	-0.0583	-0.0566	-0.0584	-0.0561
791	QF 47-49	-0.1084	NA	-0.1054	-0.1049	-0.1043	-0.1051	-0.1043
792	QF 42-49	0.0524	NA	0.0598	0.0563	0.0558	0.0569	0.0570
793	QF 42-49	0.0524	NA	0.0598	0.0563	0.0558	0.0569	0.0570
794	QF 45-49	-0.0208	-0.0209	-0.0214	-0.0205	-0.0167	-0.0206	-0.0152
795	QF 48-49	0.0321	NA	0.0362	0.0371	0.0326	0.0371	0.0316
796	QF 49-50	0.1343	NA	0.1339	0.1325	0.1314	0.1324	0.1325
797	QF 49-51	0.2044	NA	0.2013	0.1991	0.2020	0.1987	0.2018
798	QF 51-52	0.0625	NA	0.0672	0.0670	0.0622	0.0648	0.0630
799	QF 52-53	0.0199	0.0198	0.0246	0.0245	0.0200	0.0235	0.0197
800	QF 53-54	-0.0555	NA	-0.0561	-0.0554	-0.0546	-0.0534	-0.0553
801	QF 49-54	0.1307	NA	0.1331	0.1322	0.1303	0.1319	0.1298
802	QF 49-54	0.1120	NA	0.1142	0.1134	0.1114	0.1130	0.1110
803	QF 54-55	0.0146	0.0147	0.0148	0.0148	0.0147	0.0150	0.0146
804	QF 54-56	0.0435	NA	0.0477	0.0468	0.0443	0.0467	0.0433

805	QF 55-56	-0.0582	NA	-0.0562	-0.0566	-0.0579	-0.0574	-0.0581
806	QF 56-57	-0.0910	-0.0938	-0.0904	-0.0903	-0.0948	-0.0903	-0.0938
807	QF 50-57	0.0914	0.0878	0.0968	0.0957	0.0888	0.0950	0.0883
808	QF 56-58	-0.0369	NA	-0.0441	-0.0443	-0.0380	-0.0443	-0.0377
809	QF 51-58	0.0316	0.0313	0.0365	0.0367	0.0323	0.0356	0.0313
810	QF 54-59	-0.0751	NA	-0.0776	-0.0769	-0.0746	-0.0757	-0.0736
811	QF 56-59	-0.0417	NA	-0.0442	-0.0436	-0.0413	-0.0425	-0.0404
812	QF 56-59	-0.0391	NA	-0.0417	-0.0410	-0.0386	-0.0399	-0.0376
813	QF 55-59	-0.0826	NA	-0.0854	-0.0846	-0.0822	-0.0834	-0.0811
814	QF 59-60	0.0357	0.0364	0.0370	0.0370	0.0358	0.0364	0.0351
815	QF 59-61	0.0503	NA	0.0511	0.0512	0.0502	0.0506	0.0491
816	QF 60-61	0.0852	NA	0.0809	0.0811	0.0844	0.0829	0.0801
817	QF 60-62	-0.0711	-0.0736	-0.0664	-0.0666	-0.0641	-0.0636	-0.0683
818	QF 61-62	-0.1386	NA	-0.1297	-0.1302	-0.1273	-0.1263	-0.1323
819	QF 63-59	0.6748	NA	0.6751	0.6742	0.6771	0.6755	0.6786
820	QF 63-64	-0.6748	NA	-0.6751	-0.6742	-0.6761	-0.6755	-0.6783
821	QF 64-61	0.1399	NA	0.1440	0.1433	0.1416	0.1432	0.1408
822	QF 38-65	-0.5763	NA	-0.5238	-0.5619	-0.5702	-0.5665	-0.5697
823	QF 64-65	-0.6649	-0.6705	-0.6696	-0.6683	-0.6695	-0.6695	-0.6705
824	QF 49-66	0.0433	NA	0.0437	0.0437	0.0429	0.0445	0.0424
825	QF 49-66	0.0433	NA	0.0437	0.0437	0.0429	0.0445	0.0424
826	QF 62-66	-0.1726	NA	-0.1743	-0.1738	-0.1739	-0.1746	-0.1732
827	QF 62-67	-0.1441	-0.1480	-0.1494	-0.1489	-0.1490	-0.1480	-0.1480
828	QF 65-66	0.7225	NA	0.7222	0.7216	0.7285	0.7216	0.7296
829	QF 66-67	0.1927	NA	0.1916	0.1911	0.1919	0.1940	0.1911
830	QF 65-68	-0.2243	-0.2251	-0.2368	-0.2383	-0.2261	-0.2384	-0.2251
831	QF 47-69	0.1163	0.1167	0.1133	0.1132	0.1144	0.1134	0.1138
832	QF 49-69	0.1065	NA	0.1032	0.1031	0.1039	0.1032	0.1034
833	QF 68-69	1.1282	NA	1.1057	1.1045	1.1156	1.1044	1.1111
834	QF 69-70	0.1607	NA	0.1573	0.1600	0.1637	0.1582	0.1649
835	QF 24-70	-0.0297	NA	-0.0232	-0.0279	-0.0307	-0.0294	-0.0303
836	QF 70-71	-0.1238	NA	-0.1415	-0.1379	-0.1261	-0.1353	-0.1240
837	QF 24-72	0.0331	NA	0.0357	0.0314	0.0305	0.0306	0.0320
838	QF 71-72	-0.0094	-0.0094	-0.0199	-0.0147	-0.0104	-0.0124	-0.0098
839	QF 71-73	-0.1074	-0.1068	-0.1148	-0.1164	-0.1078	-0.1160	-0.1068
840	QF 70-74	0.1289	NA	0.1405	0.1376	0.1314	0.1348	0.1307
841	QF 70-75	0.0994	NA	0.1115	0.1087	0.1019	0.1054	0.1015
842	QF 69-75	0.2049	0.2124	0.2160	0.2152	0.2114	0.2097	0.2124
843	QF 74-75	-0.0619	-0.0604	-0.0577	-0.0583	-0.0614	-0.0604	-0.0604
844	QF 76-77	-0.2104	-0.2104	-0.2197	-0.2194	-0.2178	-0.2177	-0.2192
845	QF 69-77	0.0678	NA	0.0682	0.0671	0.0672	0.0662	0.0671
846	QF 75-77	-0.0955	NA	-0.1015	-0.1015	-0.0994	-0.0989	-0.1002

847	QF 77-78	0.0661	NA	0.0307	0.0303	0.0387	0.0367	0.0420
848	QF 78-79	-0.1837	-0.1824	-0.1813	-0.1808	-0.1814	-0.1803	-0.1824
849	QF 77-80	-0.3741	NA	-0.3687	-0.3678	-0.3683	-0.3661	-0.3707
850	QF 77-80	-0.2055	NA	-0.2031	-0.2027	-0.2029	-0.2019	-0.2041
851	QF 79-80	-0.2958	NA	-0.2873	-0.2867	-0.2883	-0.2868	-0.2903
852	QF 68-81	-0.0461	NA	-0.0585	-0.0598	-0.0531	-0.0598	-0.0481
853	QF 81-80	0.7554	0.7379	0.7446	0.7425	0.7494	0.7424	0.7379
854	QF 77-82	0.1755	0.1758	0.1822	0.1804	0.1765	0.1759	0.1758
855	QF 82-83	0.2439	NA	0.2518	0.2511	0.2447	0.2491	0.2437
856	QF 83-84	0.1469	NA	0.1549	0.1543	0.1500	0.1492	0.1487
857	QF 83-85	0.1200	NA	0.1269	0.1262	0.1217	0.1220	0.1211
858	QF 84-85	0.0899	0.0895	0.0882	0.0881	0.0885	0.0895	0.0895
859	QF 85-86	-0.0735	NA	-0.0731	-0.0734	-0.0734	-0.0724	-0.0724
860	QF 86-87	-0.1509	-0.1557	-0.1523	-0.1524	-0.1530	-0.1520	-0.1521
861	QF 85-88	0.0760	0.0731	0.0766	0.0763	0.0742	0.0730	0.0737
862	QF 85-89	0.0068	NA	0.0060	0.0058	0.0063	0.0056	0.0059
863	QF 88-89	-0.0247	NA	-0.0274	-0.0274	-0.0229	-0.0229	-0.0231
864	QF 89-90	-0.0472	NA	-0.0482	-0.0483	-0.0474	-0.0474	-0.0471
865	QF 89-90	-0.0544	NA	-0.0560	-0.0562	-0.0545	-0.0546	-0.0539
866	QF 90-91	0.0442	NA	0.0396	0.0393	0.0462	0.0448	0.0466
867	QF 89-92	-0.0210	NA	-0.0249	-0.0249	-0.0206	-0.0229	-0.0201
868	QF 89-92	-0.0507	NA	-0.0519	-0.0518	-0.0507	-0.0512	-0.0504
869	QF 91-92	-0.0663	-0.0663	-0.0627	-0.0623	-0.0673	-0.0663	-0.0673
870	QF 92-93	-0.1166	-0.1143	-0.1090	-0.1092	-0.1133	-0.1143	-0.1143
871	QF 92-94	-0.1521	NA	-0.1597	-0.1592	-0.1540	-0.1531	-0.1529
872	QF 93-94	-0.1950	NA	-0.2199	-0.2188	-0.2035	-0.1997	-0.1994
873	QF 94-95	0.0901	0.0934	0.0947	0.0951	0.0944	0.0934	0.0934
874	QF 80-96	0.2107	NA	0.2119	0.2107	0.2096	0.2097	0.2104
875	QF 82-96	-0.0657	-0.0648	-0.0680	-0.0681	-0.0658	-0.0628	-0.0648
876	QF 94-96	-0.0982	NA	-0.0971	-0.0962	-0.0968	-0.0979	-0.0977
877	QF 80-97	0.2575	NA	0.2592	0.2578	0.2576	0.2581	0.2588
878	QF 80-98	0.0832	NA	0.0854	0.0845	0.0852	0.0843	0.0868
879	QF 80-99	0.0817	NA	0.0820	0.0808	0.0810	0.0799	0.0817
880	QF 92-100	-0.1653	-0.1713	-0.1683	-0.1681	-0.1640	-0.1649	-0.1634
881	QF 94-100	-0.5054	NA	-0.5008	-0.5012	-0.4954	-0.5013	-0.4944
882	QF 95-96	-0.2169	-0.2188	-0.2185	-0.2176	-0.2178	-0.2188	-0.2185
883	QF 96-97	-0.2016	NA	-0.2025	-0.2016	-0.1998	-0.1992	-0.1999
884	QF 98-100	0.0243	0.0238	0.0252	0.0240	0.0248	0.0239	0.0253
885	QF 99-100	-0.0459	-0.0467	-0.0419	-0.0426	-0.0405	-0.0407	-0.0389
886	QF 100-101	0.2290	0.2323	0.2417	0.2412	0.2313	0.2274	0.2323
887	QF 92-102	-0.0839	NA	-0.0780	-0.0782	-0.0795	-0.0824	-0.0782

888	QF 101-102	0.1013	0.1027	0.0985	0.0986	0.0979	0.1027	0.0950
889	QF 100-103	-0.2215	NA	-0.2206	-0.2209	-0.2169	-0.2208	-0.2158
890	QF 100-104	0.1065	NA	0.1043	0.1040	0.1057	0.1052	0.1066
891	QF 103-104	0.1387	NA	0.1366	0.1362	0.1369	0.1376	0.1376
892	QF 103-105	0.1285	NA	0.1266	0.1262	0.1270	0.1274	0.1275
893	QF 100-106	0.0948	0.0913	0.0919	0.0915	0.0934	0.0927	0.0933
894	QF 104-105	0.0263	NA	0.0269	0.0266	0.0272	0.0262	0.0262
895	QF 105-105	0.0388	NA	0.0349	0.0348	0.0356	0.0348	0.0326
896	QF 105-107	-0.0237	NA	-0.0246	-0.0250	-0.0256	-0.0247	-0.0254
897	QF 105-108	-0.1113	-0.1074	-0.1065	-0.1068	-0.1084	-0.1080	-0.1074
898	QF 106-107	-0.0373	NA	-0.0370	-0.0373	-0.0382	-0.0371	-0.0371
899	QF 108-109	-0.1092	-0.1134	-0.1112	-0.1113	-0.1118	-0.1134	-0.1134
900	QF 103-110	0.0835	NA	0.0833	0.0828	0.0809	0.0828	0.0805
901	QF 109-110	-0.1339	-0.1392	-0.1334	-0.1335	-0.1382	-0.1345	-0.1398
902	QF 110-111	0.0096	NA	0.0120	0.0117	0.0105	0.0095	0.0095
903	QF 110-112	-0.3061	NA	-0.2953	-0.2955	-0.3024	-0.2960	-0.3034
904	QF 17-113	0.0590	0.0566	0.0649	0.0581	0.0556	0.0566	0.0566
905	QF 32-113	-0.1780	NA	-0.1846	-0.1650	-0.1759	-0.1652	-0.1757
906	QF 32-114	0.0178	NA	0.0208	0.0168	0.0187	0.0177	0.0177
907	QF 27-115	0.0506	0.0516	0.0494	0.0500	0.0506	0.0516	0.0516
908	QF 114-115	0.0022	0.0021	0.0025	0.0024	0.0031	0.0021	0.0021
909	QF 68-116	-0.6636	NA	-0.6403	-0.6400	-0.6454	-0.6400	-0.6443
910	QF 12-117	0.0520	0.0529	0.0578	0.0529	0.0528	0.0529	0.0529
911	QF 75-118	0.2359	0.2421	0.2401	0.2398	0.2411	0.2421	0.2421
912	QF 76-118	-0.0969	-0.0995	-0.0969	-0.0966	-0.0985	-0.0995	-0.0987
913	QT 1-2	0.1101	NA	0.0953	0.1061	0.1073	0.1064	0.1062

914	QT 1-3	0.1688	NA	0.1741	0.1718	0.1721	0.1714	0.1684
915	QT 4-5	0.2749	NA	0.3041	0.2820	0.2784	0.2784	0.2775
916	QT 3-5	0.1728	NA	0.1614	0.1778	0.1772	0.1763	0.1759
917	QT 5-6	-0.0130	NA	0.0035	-0.0205	-0.0154	-0.0151	-0.0184
918	QT 6-7	0.0451	NA	0.0448	0.0445	0.0457	0.0467	0.0467
919	QT 8-9	0.2443	NA	0.2955	0.2492	0.2463	0.2547	0.2447
920	QT 8-5	-0.9201	NA	-1.0084	-0.9321	-0.9273	-0.9443	-0.9155
921	QT 9-10	-0.5104	NA	-0.4892	-0.5156	-0.5204	-0.5075	-0.5226
922	QT 4-11	0.0135	NA	-0.0038	0.0120	0.0142	0.0141	0.0137
923	QT 5-11	-0.0062	NA	-0.0309	-0.0084	-0.0059	-0.0059	-0.0063
924	QT 11-12	0.3513	0.3379	0.3673	0.3375	0.3486	0.3478	0.3399
925	QT 2-12	0.1942	NA	0.2248	0.2046	0.2082	0.2075	0.2025
926	QT 3-12	0.0886	NA	0.0894	0.0892	0.0913	0.0907	0.0894
927	QT 7-12	0.0576	NA	0.0437	0.0568	0.0599	0.0589	0.0589
928	QT 11-13	-0.1216	-0.1259	0.0307	-0.1275	-0.1269	-0.1259	-0.1239
929	QT 12-14	-0.0414	NA	-0.0161	-0.0622	-0.0432	-0.0418	-0.0576
930	QT 13-15	-0.0204	-0.0202	-0.0581	-0.0223	-0.0212	-0.0202	-0.0267
931	QT 14-15	-0.0783	NA	-0.0768	-0.0741	-0.0803	-0.0792	-0.0800
932	QT 12-16	-0.0632	NA	-0.0658	-0.0694	-0.0689	-0.0699	-0.0726
933	QT 15-17	0.2522	0.2547	0.2455	0.2459	0.2456	0.2431	0.2431
934	QT 16-17	-0.0030	NA	0.0022	-0.0052	-0.0050	-0.0031	-0.0092
935	QT 17-18	-0.2240	NA	-0.2324	-0.2150	-0.2174	-0.2163	-0.2164
936	QT 18-19	-0.1755	-0.1723	-0.1810	-0.1744	-0.1778	-0.1723	-0.1764
937	QT 19-20	-0.0771	NA	-0.0908	-0.0661	-0.0740	-0.0649	-0.0740
938	QT 15-19	-0.1650	NA	-0.1852	-0.1590	-0.1659	-0.1612	-0.1663
939	QT 20-21	-0.0590	-0.0578	-0.0664	-0.0519	-0.0568	-0.0509	-0.0578
940	QT 21-22	0.0176	0.0179	0.0191	0.0186	0.0169	0.0179	0.0182
941	QT 22-23	0.0769	0.0749	0.0811	0.0766	0.0744	0.0749	0.0749
942	QT 23-24	-0.1524	NA	-0.1646	-0.1577	-0.1532	-0.1536	-0.1542
943	QT 23-25	0.3863	0.3793	0.3979	0.3875	0.3981	0.3922	0.3985
944	QT 26-25	-0.1864	-0.1919	-0.1896	-0.1779	-0.1909	-0.1782	-0.1919
945	QT 25-27	-0.1525	NA	-0.1589	-0.1516	-0.1542	-0.1516	-0.1548
946	QT 27-28	-0.0043	-0.0044	-0.0063	-0.0092	-0.0049	-0.0095	-0.0044
947	QT 28-29	0.0464	NA	0.0529	0.0441	0.0456	0.0445	0.0446
948	QT 30-17	-0.7010	NA	-0.6969	-0.7345	-0.7241	-0.7319	-0.7299
949	QT 8-30	-0.7542	-0.7834	-0.7554	-0.7615	-0.7637	-0.7539	-0.7716
950	QT 26-30	-0.3657	NA	-0.3601	-0.3803	-0.3723	-0.3829	-0.3708
951	QT 17-31	-0.1473	NA	-0.1545	-0.1343	-0.1447	-0.1340	-0.1442
952	QT 29-31	0.0792	0.0803	0.0842	0.0766	0.0809	0.0751	0.0803
953	QT 23-32	-0.0624	NA	-0.0625	-0.0635	-0.0618	-0.0626	-0.0636
954	QT 31-32	-0.1360	NA	-0.1397	-0.1290	-0.1347	-0.1293	-0.1353
955	QT 27-32	-0.0343	NA	-0.0304	-0.0341	-0.0332	-0.0350	-0.0351

956	QT 15-33	0.0149	NA	0.0167	0.0259	0.0232	0.0248	0.0227
957	QT 19-34	0.0460	0.0452	0.0510	0.0563	0.0537	0.0556	0.0537
958	QT 35-36	-0.0429	NA	-0.0487	-0.0406	-0.0422	-0.0421	-0.0418
959	QT 35-37	0.1243	0.1219	0.1299	0.1212	0.1235	0.1226	0.1219
960	QT 33-37	0.0746	0.0768	0.0792	0.0827	0.0778	0.0828	0.0798
961	QT 34-36	-0.0498	NA	-0.0478	-0.0532	-0.0527	-0.0516	-0.0516
962	QT 34-37	0.4429	NA	0.4859	0.4153	0.4311	0.4297	0.4261
963	QT 38-37	-0.8801	NA	-0.8487	-0.8583	-0.8658	-0.8596	-0.8679
964	QT 37-39	-0.0230	NA	-0.0579	-0.0303	-0.0252	-0.0235	-0.0237
965	QT 37-40	0.0296	NA	0.0087	0.0259	0.0284	0.0301	0.0299
966	QT 30-38	-0.5598	-0.5403	-0.5801	-0.5520	-0.5491	-0.5486	-0.5549
967	QT 39-40	0.0775	NA	0.0803	0.0804	0.0794	0.0804	0.0804
968	QT 40-41	-0.0221	NA	-0.0255	-0.0238	-0.0229	-0.0219	-0.0219
969	QT 40-42	0.0230	0.0221	0.0161	0.0196	0.0211	0.0199	0.0207
970	QT 41-42	0.0524	0.0527	0.0443	0.0483	0.0501	0.0481	0.0492
971	QT 43-44	-0.0379	NA	-0.0521	-0.0423	-0.0389	-0.0404	-0.0397
972	QT 34-43	-0.0567	NA	-0.0730	-0.0670	-0.0585	-0.0665	-0.0575
973	QT 44-45	-0.0662	NA	-0.0741	-0.0631	-0.0708	-0.0613	-0.0705
974	QT 45-46	0.0212	NA	0.0220	0.0215	0.0172	0.0218	0.0163
975	QT 46-47	-0.0079	-0.0080	-0.0079	-0.0084	-0.0090	-0.0083	-0.0091
976	QT 46-48	0.0142	NA	0.0143	0.0141	0.0123	0.0143	0.0119
977	QT 47-49	0.0928	NA	0.0898	0.0892	0.0887	0.0895	0.0887
978	QT 42-49	0.0037	0.0037	-0.0047	-0.0006	-0.0013	-0.0011	-0.0012
979	QT 42-49	0.0037	0.0038	-0.0047	-0.0006	-0.0013	-0.0011	-0.0012
980	QT 45-49	0.0231	NA	0.0229	0.0220	0.0183	0.0223	0.0174
981	QT 48-49	-0.0393	-0.0388	-0.0433	-0.0442	-0.0398	-0.0443	-0.0388
982	QT 49-50	-0.1314	-0.1303	-0.1315	-0.1301	-0.1293	-0.1303	-0.1303
983	QT 49-51	-0.1740	-0.1775	-0.1698	-0.1677	-0.1706	-0.1676	-0.1710
984	QT 51-52	-0.0699	-0.0721	-0.0747	-0.0744	-0.0697	-0.0721	-0.0704
985	QT 52-53	-0.0545	NA	-0.0591	-0.0590	-0.0546	-0.0580	-0.0543
986	QT 53-54	0.0299	NA	0.0306	0.0300	0.0291	0.0279	0.0297
987	QT 49-54	-0.1560	-0.1577	-0.1578	-0.1569	-0.1552	-0.1565	-0.1549
988	QT 49-54	-0.1379	NA	-0.1396	-0.1387	-0.1370	-0.1383	-0.1368
989	QT 54-55	-0.0325	NA	-0.0327	-0.0327	-0.0327	-0.0329	-0.0326
990	QT 54-56	-0.0498	-0.0496	-0.0540	-0.0530	-0.0506	-0.0530	-0.0496
991	QT 55-56	0.0557	0.0538	0.0537	0.0541	0.0553	0.0549	0.0555
992	QT 56-57	0.0749	NA	0.0742	0.0741	0.0785	0.0741	0.0774
993	QT 50-57	-0.1049	NA	-0.1094	-0.1083	-0.1013	-0.1073	-0.1009
994	QT 56-58	0.0153	0.0153	0.0225	0.0227	0.0163	0.0227	0.0161
995	QT 51-58	-0.0453	NA	-0.0502	-0.0504	-0.0461	-0.0494	-0.0451
996	QT 54-59	0.0426	0.0432	0.0450	0.0444	0.0420	0.0432	0.0412
997	QT 56-59	0.0099	NA	0.0123	0.0117	0.0094	0.0106	0.0085

998	QT 56-59	0.0113	0.0113	0.0138	0.0132	0.0108	0.0121	0.0099
999	QT 55-59	0.0588	NA	0.0615	0.0608	0.0583	0.0596	0.0574
1000	QT 59-60	-0.0440	NA	-0.0452	-0.0452	-0.0438	-0.0444	-0.0431
1001	QT 59-61	-0.0463	-0.0476	-0.0471	-0.0470	-0.0461	-0.0465	-0.0450
1002	QT 60-61	-0.0823	-0.0831	-0.0784	-0.0785	-0.0821	-0.0803	-0.0779
1003	QT 60-62	0.0574	NA	0.0525	0.0528	0.0501	0.0497	0.0544
1004	QT 61-62	0.1320	NA	0.1232	0.1237	0.1210	0.1197	0.1259
1005	QT 63-59	-0.5702	-0.5856	-0.5698	-0.5689	-0.5725	-0.5701	-0.5746
1006	QT 63-64	0.5251	0.5083	0.5256	0.5250	0.5269	0.5263	0.5293
1007	QT 64-61	-0.1368	NA	-0.1407	-0.1400	-0.1384	-0.1399	-0.1378
1008	QT 38-65	-0.0837	NA	-0.1394	-0.0989	-0.0934	-0.0949	-0.0919
1009	QT 64-65	0.4006	NA	0.4072	0.4065	0.4073	0.4078	0.4078
1010	QT 49-66	0.0832	0.0853	0.0836	0.0838	0.0843	0.0829	0.0852
1011	QT 49-66	0.0832	NA	0.0836	0.0838	0.0843	0.0829	0.0852
1012	QT 62-66	0.1468	0.1514	0.1496	0.1491	0.1492	0.1500	0.1481
1013	QT 62-67	0.1215	NA	0.1271	0.1267	0.1263	0.1258	0.1252
1014	QT 65-66	-0.7055	-0.6965	-0.7053	-0.7047	-0.7113	-0.7047	-0.7124
1015	QT 66-67	-0.1915	-0.1917	-0.1895	-0.1890	-0.1888	-0.1917	-0.1883
1016	QT 65-68	-0.4185	NA	-0.4070	-0.4047	-0.4181	-0.4046	-0.4190
1017	QT 47-69	-0.1007	NA	-0.0979	-0.0977	-0.0990	-0.0978	-0.0981
1018	QT 49-69	-0.1206	-0.1240	-0.1177	-0.1174	-0.1185	-0.1177	-0.1177
1019	QT 68-69	-1.0364	-1.0038	-1.0166	-1.0154	-1.0262	-1.0153	-1.0219
1020	QT 69-70	-0.1398	NA	-0.1370	-0.1391	-0.1438	-0.1380	-0.1453
1021	QT 24-70	-0.0680	-0.0701	-0.0749	-0.0699	-0.0672	-0.0684	-0.0677
1022	QT 70-71	0.1168	NA	0.1346	0.1311	0.1191	0.1285	0.1170
1023	QT 24-72	-0.0798	-0.0776	-0.0829	-0.0784	-0.0774	-0.0776	-0.0789
1024	QT 71-72	-0.0315	NA	-0.0212	-0.0261	-0.0306	-0.0284	-0.0312
1025	QT 71-73	0.0965	NA	0.1039	0.1055	0.0969	0.1052	0.0959
1026	QT 70-74	-0.1542	-0.1599	-0.1654	-0.1626	-0.1567	-0.1599	-0.1560
1027	QT 70-75	-0.1317	NA	-0.1435	-0.1407	-0.1342	-0.1375	-0.1338
1028	QT 69-75	-0.1831	NA	-0.1935	-0.1925	-0.1894	-0.1877	-0.1906
1029	QT 74-75	0.0644	NA	0.0599	0.0605	0.0636	0.0626	0.0626
1030	QT 76-77	0.2439	NA	0.2542	0.2541	0.2522	0.2521	0.2534
1031	QT 69-77	-0.1380	-0.1372	-0.1391	-0.1380	-0.1382	-0.1372	-0.1381
1032	QT 75-77	0.0738	0.0760	0.0803	0.0803	0.0780	0.0775	0.0787
1033	QT 77-78	-0.0763	NA	-0.0408	-0.0404	-0.0488	-0.0469	-0.0521
1034	QT 78-79	0.1795	NA	0.1771	0.1766	0.1772	0.1761	0.1782
1035	QT 77-80	0.3753	NA	0.3701	0.3693	0.3696	0.3675	0.3721
1036	QT 77-80	0.2059	NA	0.2037	0.2033	0.2034	0.2024	0.2046
1037	QT 79-80	0.3108	0.2989	0.3025	0.3020	0.3035	0.3020	0.3055
1038	QT 68-81	-0.7554	NA	-0.7446	-0.7425	-0.7504	-0.7424	-0.7551
1039	QT 81-80	-0.7305	NA	-0.7201	-0.7180	-0.7247	-0.7179	-0.7138

1040	QT 77-82	-0.2528	NA	-0.2595	-0.2577	-0.2541	-0.2533	-0.2533
1041	QT 82-83	-0.2699	-0.2697	-0.2776	-0.2769	-0.2707	-0.2750	-0.2697
1042	QT 83-84	-0.1599	NA	-0.1677	-0.1671	-0.1629	-0.1622	-0.1614
1043	QT 83-85	-0.1229	NA	-0.1295	-0.1288	-0.1243	-0.1249	-0.1239
1044	QT 84-85	-0.0924	NA	-0.0908	-0.0906	-0.0909	-0.0921	-0.0923
1045	QT 85-86	0.0509	0.0497	0.0504	0.0507	0.0507	0.0497	0.0497
1046	QT 86-87	0.1102	0.1112	0.1117	0.1118	0.1122	0.1112	0.1112
1047	QT 85-88	-0.0753	NA	-0.0764	-0.0761	-0.0734	-0.0730	-0.0737
1048	QT 85-89	0.0373	NA	0.0379	0.0381	0.0382	0.0380	0.0375
1049	QT 88-89	0.0770	0.0756	0.0804	0.0804	0.0755	0.0756	0.0756
1050	QT 89-90	0.0581	NA	0.0597	0.0598	0.0586	0.0587	0.0581
1051	QT 89-90	0.0707	0.0725	0.0735	0.0737	0.0713	0.0716	0.0704
1052	QT 90-91	-0.0646	NA	-0.0601	-0.0597	-0.0667	-0.0652	-0.0671
1053	QT 89-92	0.1696	NA	0.1731	0.1731	0.1696	0.1701	0.1673
1054	QT 89-92	0.0729	NA	0.0740	0.0740	0.0730	0.0730	0.0721
1055	QT 91-92	0.0359	NA	0.0322	0.0319	0.0368	0.0359	0.0368
1056	QT 92-93	0.1250	NA	0.1171	0.1172	0.1213	0.1222	0.1222
1057	QT 92-94	0.1591	0.1633	0.1671	0.1667	0.1620	0.1601	0.1600
1058	QT 93-94	0.1944	NA	0.2203	0.2192	0.2043	0.1996	0.1995
1059	QT 94-95	-0.0931	NA	-0.0976	-0.0980	-0.0973	-0.0962	-0.0963
1060	QT 80-96	-0.2462	NA	-0.2475	-0.2463	-0.2454	-0.2453	-0.2460
1061	QT 82-96	0.0129	NA	0.0151	0.0152	0.0129	0.0099	0.0119
1062	QT 94-96	0.0798	0.0799	0.0785	0.0777	0.0782	0.0794	0.0791
1063	QT 80-97	-0.2719	NA	-0.2736	-0.2721	-0.2720	-0.2725	-0.2732
1064	QT 80-98	-0.1043	-0.1038	-0.1065	-0.1056	-0.1063	-0.1054	-0.1078
1065	QT 80-99	-0.1294	NA	-0.1298	-0.1286	-0.1289	-0.1277	-0.1295
1066	QT 92-100	0.1537	NA	0.1571	0.1570	0.1528	0.1533	0.1517
1067	QT 94-100	0.4581	0.4462	0.4530	0.4535	0.4472	0.4536	0.4462
1068	QT 95-96	0.2051	NA	0.2067	0.2057	0.2059	0.2070	0.2067
1069	QT 96-97	0.1819	0.1884	0.1827	0.1819	0.1799	0.1793	0.1800
1070	QT 98-100	-0.0730	NA	-0.0739	-0.0728	-0.0736	-0.0726	-0.0741
1071	QT 99-100	0.0279	NA	0.0238	0.0245	0.0225	0.0227	0.0209
1072	QT 100-101	-0.2513	NA	-0.2632	-0.2627	-0.2534	-0.2498	-0.2544
1073	QT 92-102	0.0813	NA	0.0753	0.0755	0.0770	0.0796	0.0755
1074	QT 101-102	-0.1113	NA	-0.1086	-0.1086	-0.1077	-0.1127	-0.1053
1075	QT 100-103	0.2436	0.2370	0.2418	0.2421	0.2380	0.2421	0.2370
1076	QT 100-104	-0.0941	NA	-0.0934	-0.0930	-0.0946	-0.0940	-0.0953

1077	QT 103-104	-0.1583	NA	-0.1569	-0.1566	-0.1571	-0.1577	-0.1577
1078	QT 103-105	-0.1348	NA	-0.1339	-0.1334	-0.1340	-0.1343	-0.1343
1079	QT 100-106	-0.0712	NA	-0.0702	-0.0698	-0.0713	-0.0704	-0.0710
1080	QT 104-105	-0.0261	-0.0260	-0.0267	-0.0264	-0.0270	-0.0260	-0.0260
1081	QT 105-105	-0.0515	-0.0506	-0.0477	-0.0476	-0.0484	-0.0476	-0.0454
1082	QT 105-107	-0.0055	NA	-0.0049	-0.0045	-0.0039	-0.0046	-0.0040
1083	QT 105-108	0.0992	NA	0.0943	0.0946	0.0963	0.0958	0.0952
1084	QT 106-107	0.0055	0.0053	0.0051	0.0054	0.0063	0.0053	0.0053
1085	QT 108-109	0.1039	0.1055	0.1059	0.1059	0.1065	0.1081	0.1081
1086	QT 103-110	-0.0615	NA	-0.0624	-0.0618	-0.0596	-0.0614	-0.0593
1087	QT 109-110	0.1177	NA	0.1172	0.1173	0.1221	0.1183	0.1237
1088	QT 110-111	-0.0184	NA	-0.0210	-0.0208	-0.0196	-0.0186	-0.0186
1089	QT 110-112	0.2851	NA	0.2728	0.2731	0.2802	0.2736	0.2812
1090	QT 17-113	-0.0665	NA	-0.0725	-0.0655	-0.0631	-0.0641	-0.0641
1091	QT 32-113	0.1340	0.1336	0.1401	0.1199	0.1317	0.1201	0.1314
1092	QT 32-114	-0.0322	-0.0322	-0.0354	-0.0313	-0.0332	-0.0322	-0.0322
1093	QT 27-115	-0.0653	NA	-0.0642	-0.0646	-0.0652	-0.0662	-0.0662
1094	QT 114-115	-0.0047	NA	-0.0050	-0.0049	-0.0057	-0.0047	-0.0047
1095	QT 68-116	0.5132	0.4934	0.4896	0.4895	0.4944	0.4895	0.4934
1096	QT 12-117	-0.0800	#N/A	-0.0861	-0.0810	-0.0810	-0.0809	-0.0811
1097	QT 75-118	-0.2356	#N/A	-0.2398	-0.2395	-0.2407	-0.2417	-0.2417
1098	QT 76-118	0.0856	#N/A	0.0855	0.0852	0.0871	0.0882	0.0873

Vitae

Name :Mohammad Shoaib Shahriar

Nationality :Bangladeshi

Date of Birth :12/30/1988

Email :shoebeee05@gmail.com

Address :Flat E1, Plot 160-161, Road 3, Block A, Bashundhara Residential area, Baridhara, Dhaka-1212, Bangladesh.

Academic Background : Bachelor of Science (B.Sc.) Engineering in Electrical and Electronic Engineering from Islamic University of Technology (IUT), Gazipur, Bangladesh in 2009.

Master of Science (M.Sc.) Engineering in Electrical and Electronic Engineering from Islamic University of Technology (IUT), Gazipur, Bangladesh in 2012.

- Research fields: State estimation of power system; machine learning and optimization techniques and their applications in power system; power system stability and damping techniques of low frequency oscillations; Power system operation, planning, protection and reliability.
- Google Scholar research profile: https://scholar.google.com/citations?hl=en&user=_bZ8Bm0AAAAJ
- Publications from the dissertation: presented in chapter 7.3